A
Major Project Report
On

"Odour Problems in Flexible Packaging Materials"

Submitted In Partial Fulfillment of the Requirement
For
The Award of the Degree

MASTER OF TECHNOLOGY
IN
POLYMER TECHNOLOGY

Submitted by
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(2012)

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CERTIFICATE

This is to certify that the dissertation entitled **"Odour Problems in Flexible packaging Materials"** submitted by Mr. *Rajendra Pratap Singh* to Delhi Technological University in Applied Chemistry and Polymer Technology is a record of bonafide work carried out by him. Mr. *Rajendra Pratap Singh* has worked under our guidance and supervision for fulfilled the requirement for the submission of this dissertation.

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ACKNOWLEDGEMENTS

Taking the opportunity of this column, I would like to express my sincere gratitude to all those who directly or indirectly helped me in successful completion of my Project work.

My heartfelt thanks to my mentor and guide **Professor. R.C. Sharma**, Department of Applied Chemistry & Polymer Technology, Delhi Technological University, who provided me an opportunity to work under his able guidance. His valuable guidance and motivation has helped me to complete my project successfully.

I would like to convey my heartiest thanks my Co- Supervisor ***Mr. N. Siva Shankaran*** who introduced me to the field of Polymer Packaging, offered his vision and guidance in planning experiments, and led me to a proper understanding of the experimental results.

I express my grateful thanks to **Professor. G. L. Verma,** Head, Department of Applied Chemistry & Polymer Technology, Delhi Technological University and all the faculty members of the departments for their valuable suggestions and help.

I am extremely grateful to all members of Quality Control Lab where I conducted most of my research work of the project. I would also like to thank ***Mr. Baijnath Pratap, Mr. Ankur Srivastava, Mr. Yogesh, Mr. R.V Singh, Mr. Vipin*** and all the members of lab.

I am highly thankful to **Mr. Rajesh, Mr. Naveen** and **Mr. Tarun** for their technical help during my work.

Last, but not the least, my parents, my brothers and sisters and my well-wishers have been with me at every step of this exciting journey. I thank them for all their prayers, encouragements and best wishes.

Thank you all

Rajendra Pratap Singh

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2.0 LITERATURE SURVEY

Abstract

These days packaging food market not only in India but also in all over world is increasing rapidly. As we seen that mostly food products available in market are packed by packaging materials. Packaged food products are transported all over world which takes some time ranging from few to many days, for this purpose we should consider about safety and quality of the food products. As my thesis title is "Odour Problem in Flexible Packaging Materials" my work is to find out that what are the main causes of odour in flexible packaging material and what is intensity of odour in different packaging film. Off-odour may be classified as a common type of failure. Base packaging material can itself contain solvent residues either from coatings or where the base packaging material that is laminated from an adhesive. Such solvent residues can be ethyl acetate, toluene and THF, all of which have strong odours. Printing Ink also often contain solvents with well-defined odours. To find out the value of solvent retention and intensity of odour we have performed the Gas- Chromatography and Jar-Odour test. we have performed the GC test for 8 samples, out of which 5 were monolayer and rest were double layer. After the operation of GC, we have compared the obtained value of solvent retention of following chemicals EA, IPA, MIBK, MEK, Toluene, Ethanol and N Propyl acetate with permissible value provided by Uflex Private Limited and Food and Drug Administration (FDA). After comparison we have found that the obtained values of solvent retention was much lower than the permissible values, hence the obtained result is satisfactory. After that we have performed the Jar-odour test for the same 8 samples, odour in monolayer samples found to be comparatively lower than the double layer samples and intensity level in all the 8 samples are below objectionable level and results are acceptable. .

CHAPTER-1 INTRODUCTION

Packaging is defined as the process (such as cleaning, drying, preserving) and materials (such as glass, metal , paper or paperboard, plastic) employed to contain, handle, protect to the article.

Packaging is the way goods are wrapped either by the manufacturer or the distributor before being sold or handed over to the final consumer/end user. A good packaging should keep the product clean, should prevent losses, contaminations, chemical and physical damages and must provide identification and instruction.

1.1 Necessity of Packaging:

- For extending the shelf life of the product to be packed.
- To prevent the product from physical changes that is non enzymatic browning, discoloration.
- To save from biological deterioration that is from micro-organism, enzymatic activities, insect infection, rodent infestation
- For cost saving in storage and transportation.
- It gives aesthetic look to the product.
- Easy handling.
- For transportation and storing of product.
- To carry information and colorful design that makes attractive display

1.2 Parameters for selecting packaging materials:

- Economy

- Protection of the product to be packed.
- Life of the package that is life of the package must exceed the life of the product.
- The package must give protection prior to use and in many cases during the use of the product.
- Optimizes the use of renewable or recycled source materials.
- Meets market criteria for performance and cost.
- Should not cause any reaction with food products.
- There should have barrier for oxygen/air permeability.
- There should be proper permeability for nitrogen.
- It should have grease resistance properties.
- Light sensitivity of the packaging material should be according to the food product.
- It should gives information about the food product.
- Packaging materials should provide long shelf life to the product.
- Packaging materials should have compatibility with food products.

1.3 Protection offered by the Packaging:

There are two types of protection offered by the packaging

i). Active protection

ii). Passive protection

i) Active Protection:

In active protection, packaging is designed for a particular preservation such as :

- Aseptic packaging as In Tetra-Packs.

- Sterilization using tin plate scans and sealed bottling jars.
- Preservation under modified atmosphere.
- Special packaging example bags with a valve for release of external pressure.

ii) Passive packaging

This serves mainly as a barrier between the product and external medium. It is independent of the food stuff preparation and preservation techniques. Passive packaging gives protection against:

1) Light
2) Heat
3) Mechanical damage
4) Protection from microorganism in the atmosphere
5) Protection from gas and water vapour

1.4 Aseptic packaging:

A method of heating food without destruction of proteins. In this process a very high temperature of about 121^{O} C is applied for a very short period of about ~2 sec to destroy micro-organisms without causing any change in the proteins. E.g. is long life milk is a typical example of this method.

1.5 Modified atmosphere packaging:

It involves storage of foods or vegetables in a modified atmosphere for this purpose 3 gases are used

1) CO_2

2) O_2

3) N_2

- CO_2 is largely used because of its retardness of growth of microorganism.
- O_2 should be as low as possible. It is used mainly meat like product where color retention is desired.
- N_2 is largely used to displace oxygen and delay oxygen. It is also used as a filler gas to prevent vacuum to occur.

Advantages :

- It increases the shelf life of product by a few days to few weeks.
- It does not change the taste of the product and is safe
- Reduces the loss of moisture and texture
- Reduces the rate of oxidation
- Reduces the growth of microorganism
- Avoid weight loss
- Improves the color

Disadvantages:

- Visibly added cost
- Variable product requirements that is different gas formulation needed for each product types.
- Not universally effective

- Temp. control necessary
- Atmosphere maintenance
- Special equipment and training

1.6 Classification of Packaging

On the basis of level of packaging it is classified as-

i) Primary Packaging:

A primary package is the one which is in direct contact with the contained product. It provides the initial, and usually the major protective barrier.

ii) Secondary Packaging:

A secondary package contains a number of primary packages. It is outside the primary packaging perhaps used to group primary packages together. It is the physical distribution carrier and is sometimes designed so that it can be used in retail outlets for the display of primary packages. e.g. Corrugated case, Boxes.

iii) Tertiary Packaging:

A tertiary package is made up of a number of secondary packages. It is used for bulk handling. Example being a stretch-wrapped pallet of corrugated cases.

iv) Quaternary Packaging:

A quaternary package is frequently used to facilitate the handling of tertiary packages. This is generally a metal container up to 40 m in length which can be transferred to or from ships, trains, and flatbed trucks by giant cranes.

Packaging can be broadly classified into three categories: Rigid, Semi Rigid and Flexible packaging;

i) Rigid Plastics:

Rigid Plastics are solid plastic containers of various types including bottles, cans and plastic jars. These products are often products of low value added. Local manufacturers have only emerged in recent years.

Demand for rigid plastics is estimated to be growing at 20% per annum. Many of the local producers are involved in the production of jerry cans and buckets. However, there is increased demand for plastic bottles given the growing number of pharmaceutical and fruit juice processing industries plus the absence of glass bottle manufacture

ii) Semi rigid Packaging:

They lie in between the rigid and flexible packaging for example toothpaste and cosmetic tubes. Typical applications include part of the packaging process for biscuits, processed foods or fruits. The plastic wrap is also used to package chicken and other meat products. A distinguishing factor of these products is that they are thermo formed rather than injection or blow molded. There exists an opportunity for new investors to take care of the packaging of the growing poultry, food and horticultural industry.

iii) Flexible Packaging:

This covers a wide range of products from simple plastics with a print contact to more elaborate multi-layer plastics with or without print. Presently, both the demand for and supply of this family of products is limited. By its very nature, high value added flexible packaging tends to be associated with the packaging of high value added products. In many applications, flexible packaging has replaced the rigid packages due to their several advantages. These are Light weight & have following properties;

- Excellent barrier and functional properties
- Easy to handle and convenient for retailers and customers
- Provides much more product per a given amount of package
- Tremendous savings in raw material consumption
- Acquire the shape of the product to be packed
- Cost saving in storage and transport due to its length, weight and small size

In flexible packaging, various films like PET, BOPP, PAPER, and foils used as a single layered or multilayer with each side printed or non printed. The conversion of a films to a printed or unprinted laminate is called converting process. It goes through following steps-

(a) Printing Process :

It is the first step, which is used to decorate the product, to give product information, various instructions etc. Printing is done onto almost every film but Polyester films are the most preferred one because of their good ink adhesion characteristics.

(b) Laminating Process :

These printed films are then combined with various films to give the products desired properties like mechanical properties, barrier properties, heat sealability etc. This is done with the help of suitable adhesives which is applied to either or both the sides of substrate.

(c) Slitting Process :

Flexible packaging materials generally do not have perfectly flat surfaces. In the slitting process, the laminated web is cut to give specific width and defected material is removed from the laminated rolls with the help of sharp blade, before dispatching the material to the pouching.

(d) Pouching :

The web from the roll is converted to the pouches as per the customer/product requirements. Versatility of various kinds of pouches is enhanced by using different accessories like rope handle, punch handles, spouts ,performed handles, self sticking tape zipper, pilfer proof membrane etc.

1.7 What is Odour?

" Since all materials have some odour, aims to detect anything that is stronger than normal, unusual or unpleasant ."

An important goal in creating packaging for foods, beverages, and other goods sensitive to odour and taste is to minimize sensory change as much as possible over the shelf lives of these products. Preserving the taste and odor of products in plastic packaging is a complex process that extends throughout a package's path from formulation to customer.

Even as plastic packaging protects its contents, it can alter their taste and odor. In most cases this is subtle and of little consequence. In some cases, the change can be critical. A glaring example is neutral products like bottled water that are especially susceptible to organoleptic influences. Given the resources that food, beverage and other manufacturers expend in creating compelling products, the last thing they need is to have a plastic package alter the taste and odor of their offerings.

More and more, everyone involved in the chain of the package's creation, from the additive masterbatch suppliers and compounders to molders and extruders, are asked to validate that a package won't cross-contaminate a food or a beverage. This makes it critical to ensure that the materials used and the processing steps followed affect the odour or taste of the contents their organoleptic qualities as little as possible.

Taste and odor issues most often occur when a component in the plastic migrates into the contents of the package, although other mechanisms such as "scalping" (chemical interaction between the package and its contents) may also be present. An important initial step is to learn which package ingredients cause off-flavors and aromas so the additive and resin combination chosen has minimal organoleptic impact.

Once package prototypes have been developed, the choice of packaging raw materials is often confirmed by taste and odor panels and perhaps by analytical methods. Getting the package formulation right the first time saves time and money in package development, accelerates time to market, and eliminates costly packaging rework and requalification later on. It also ensures consumer acceptance.

1.8 Organoleptic screening

Taste and odor are psychophysical phenomena that vary from person to person. As subjective perceptions, they are best evaluated by panels of carefully selected individuals trained to detect them. Packagers of beverages like wine, liquor, coffee, and water, as well as foods, drugs, perfumes, cosmetics, and other fragrant health and beauty aids, have a long history of reliance on taste and odor panels to assess aroma and flavor.

Molders and manufacturers often use such panels to screen prototype packaging to see if the organic and inorganic ingredients and processing method used affect the organoleptic integrity of the contents. Testing panels are also used in quality-control programs during production to evaluate incoming raw materials or respond to customer complaints. Panels also come into play after a package is reformulated.

At times there is a need to identify offending substances in a package so the source of the problem can be found and corrected. Characterizing such substances is a daunting and time-consuming task. While gas chromatographs (GC) and mass spectrometers (MS) provide objective measurement of specific chemicals, this approach is limited because flavor involves trace levels of a great many compounds interacting with the human sensory apparatus.

Off-odour may be classified as a common type of failure. Base packaging material can itself contain solvent residues, either from coating or, where the base packaging material is a laminate, from an adhesive. Such solvent residues can be ethyl acetate, toluene and THF, all of which have strong odours. Printing inks also often contain solvents with well-defined odours. A criterion for selection of a solvent for use in packaging manufacture, e.g. for printing inks, is a high odour threshold (OT) value (10-100 mg/m^3). There are no generally agreed maximum levels for residual solvents in food packaging. The total level of residual solvents should preferably not exceed 30 $mg/m^{3,}$ for some of the more odorous solvents, such as isopropyl acetate, individual levels should not be less than $5mg/m^3$. Some types of packaging, particulary printed materials, can have detectable odours immediately after production but lose much of the odour during normal storage before use.

1.9 Objective & Scope of the Project:

An important goal in creating packaging for foods, beverages, and other goods sensitive to odour and taste is to minimize sensory change as much as possible over the shelf lives of these products. Preserving the taste and odor of products in plastic packaging is a complex process because package/product interaction involving scalping or other flavor system modification. The influence of off-odours or flavors on consumers has become more than quality issue with the increased awareness of the public of food safety problems.

Taste and odor issues most often occur when a component in the plastic migrates into the contents of the package, although other mechanisms such as “scalping” (chemical interaction between the package and its contents) may also be present. An important initial step is to learn which package ingredients cause off-flavors and aromas so the additive and resin combination chosen has minimal organoleptic impact.

So our main objective of the project is to find out what are the main causes of odour in the different flexible packaging materials and what is the intensity of odour in them. So that we will be able to minimize such factors and will be able to preserve the aroma and taste of the food product.

CHAPTER 2 LITERATURE SURVEY

2.1 Types of films and materials

The processing of any plastic into a film calls for the plastic to be melted, fed into a shaping exit die at a metered rate, cooled and fed to a wind-up station. Many variants and complexities can be added to this simple concept. The die can be flat or annular for either cast or tubular films.

All flexible packaging, films, laminates, paper, foil, cartons, cases, bags, pouches, labels, all start as material on a reel. Then the converters add value by printing, shaping, coating, metallizing, laminating, stamping, slitting, forming, folding.

2.1.1 Poyethylene films

The PE films are the largest tonnage of all plastics films. Originally, low density polyethylene PE-LD, were the first plastics films in current use, back in the 1950s.

In spite of downgauging, increasing environmental requirements and the greater use of recycled materials, the average annual growth rate of PE films ranges 1-3 % in the industrialized countries. In the rest of the world, the rate of growth is much higher, up to 10 % a year.

Consumption of PE films in Europe, all types, in thousands of tons, estimates in 2005 ;

Types of films	Consumption
Shrink films, collating and pallets	1000
Stretch films, hand and machine	900
Film for automatic machine wrap	600
Other films for coating, lamination, multilayers	700
Heavy duty bags	450
Other industrial bags, large bags, liners	450
Shopping, retail, household bags	700
Refuse bags	500
Films for agriculture	500
Films for building construction	400
All other films, diapers,	600
Total estimated	**6800**

2.1.2 Polypropylene films:

There are two types of PP films, oriented and cast.

There are more than 200 BOPP film producers worldwide, the ten largest accounting for 40 % of the market. The recent increases in BOPP film capacity have been in China, with a proliferation of small plants, often for in-house manufacturing of capacitor films, tapes, labels, and packaging. While the BOPP film industry is quite fragmented in China, there are a few larger scale players emerging.

The global BOPP film demand is to grow an average 7% per annum, the demand in Asia accounting for more than half of this global growth. World consumption of BOPP should reach 6 million tons by 2010, of which China will be at least 1 million tons.

The main use of OPP filme are;

Food packaging is the main application	70 % of total OPP consumption
Adhesive tapes	15 %
Tobacco	3 %, and going down
All other applications, including capacitors	12 %

BOPP films dominate snack food packaging and provide effective barrier when layered with EVOH or metallized. Other important applications are chips, biscuit, confectionery, dry and fresh bread.

2.1.3 PVC films:

One of the earliest plastics produced in quantity was PVC, and it is still an important film material, although fast decreasing. The distinction between film and sheet is slightly blurred as there is a large category of thin rigid films that can be thermoformed, yet thin enough to be called film. As a rule, the suppliers, for each of their products, offer a thickness range of 50 to 900 microns and over, making the distinction between film and sheet quite uncertain, and only applicable through detailed analysis of each of the very many applications.

The split of thin PVC film applications in Europe, about 400 000 tons total, is estimated:

Packaging total	70 %, for food, non food, visual packaging, display shrink, pharmaceutical blisters
Adhesive tapes	9 %
Technical applications	21 %, print, stationery, furniture, cards, others

With technical applications such as furniture coverings, the safety aspect of fire resistance plays an important role, as the chlorine atom present in the PVC molecule has built-in flame retardancy.

2.1.4 PET films:

The total consumption of PET film in the world was estimated at 2.2 million tons in 2005, up from 1.2 million in 1997, because of sustained growth in packaging applications. Out of this total consumption, the captive market is estimated at 250 000 tons, held by photographic, reprographic and magnetic tape making. The merchant market develops most of the growth, because of the very active demand in packaging.

The outlook for the years 2005 to 2015 gives an average annual growth of 5% led by new applications in packaging, the growing demand in Asia and less developed countries, and slowed down by downgauging in packaging, sharp decline in magnetic tape, stagnation in other applications.

The thin PET film continues to grow very actively in Asia, particularly India and Indonesia. The growth in packaging is slightly slower in the industrialized countries, yet kept up with a number of niches and specific applications such as metallized films for packaging.

2.1.5 Polyamides films:

Polyamide is widely used as one functional element in flexible food packaging and multilayer films, due to a unique combination of properties, toughness, transparence, medium barrier.

There are three categories of nylon films:

Oriented PA, bi-axially, or BOPA, and mono oriented PA, OPA, altogether	10%/y growth
Cast PA films, used for lamination with PE, in medium barrier multi-layer films	Stagnant
PA 6 resin used for coextrusion with PE, growing, yet more slowly than the BOPA films	3 %

Nylon film is not really threatened by other plastic films in its specific market niches. The oriented laminates are particularly appreciated for the good mechanical resistance, against puncture and tearing. A 15 µm OPA film has twice the puncture resistance of a 12 µm PET film.

The production of oriented nylon films has long been, and still is, a fairly small club. There have long been licenses, for the machines, that have limited the entry of new producers.

There are a relatively limited number of applications. The main uses are:

Hard cooked cheese, about	45 % of total
Other cheese, about	5%
Coffee	5%
Processed meat, fish, smoked salmon, lidding	30 %
Other food	5 %
Non food packaging	10 %

2.2 The main material /processes to achieve barrier :

- Aluminium foil, the oldest of barriers used in packaging, back to the 1930s
- Polymeric systems, PVDC, EVOH, PVOH, PAN, MXD6, LCP, coated, laminated or coextruded
- Metallized PET, and other plastics substrates as well
- Inorganic oxide coatings, alumina or silica
- Nanocomposites
- Plasma techniques

In this narrower sense of barrier, to oxygen, the main plastics used in packaging can be arranged into three categories:

- Little or no barrier to oxygen, PS. PE, PP

- Average barrier, PVC, PA, PET
- High barrier, PVDC, EVOH, PAN, PAMXD6

The first applications of barrier materials, whether in film or sheet, were for standard, long - known products.

The coextruded barrier films, the dominating and still fastest growing segment at the moment, are used in:

- Bag - in - box for wines, fruit juices, milk, tomato paste, medical products, from 2 to 1 000 liters.
- Wrap for processed meat, delicatessen packaging
- Packages for the keeping and aging of cheese
- Controlled atmosphere flush packs for supermarket fresh meat cuts.

More generally, high barrier films are used for CAP, controlled atmosphere packaging, for all kinds of longer shelf life packaging under gas flush.

2.3 Multilayer films:

There are innumerable constructions for coextruded multilayers, many that seem practically custom designed for their specific use.

Simply, the basic structure of multilayer films is made of three basic types of components:

- An outer layer, to provide protection against abrasion and scratches during processing and packaging operations. It must be printable, direct or reverse, and resistant to temperatures required to melt the sealant.

- The middle layer provides the barrier to gas permeation. It may be EVOH or PVDC and others. In the case of EVOH used with polyolefins, there must be tie-layer between the polyolefins and EVOH.
- The inner layer provides a hermetic seal by melting at selected temperatures. The most used sealants are PE, EVA and ionomers.

The requirements for the selection of multi-layers are unlimited. The key idea is that the price/performance ratio is better achieved with the synergy of the layers than with a single material.

2.4 Organoleptic product quality:

Organoleptic is defined as "capable of being perceived by one or more sense organs", where the common senses are touch, hearing, smell, taste and sight. The perception of odour/taste is a key factor for product quality and usually derives from a combination of chemical components. Complex issues such as off-odours, off-taste, contamination in raw materials, intermediates and final products can be detrimental to the quality of a product, comfort and impact on health, and are major causes of consumer complaints worldwide. Emissions from polymers in the end application often cause nuisance smells ("plastic" or "rubber"-like) and affect air quality, especially in closed spaces, and taste performance in liquid packaging applications. As many trains, aircrafts, in buildings and factories, it is necessary to select polymers with low emission of (potentially hazardous) volatile compounds. This also calls for sensitive and selective ways to characterize volatile organic chemicals (VOCs) and to identify/taste odour sources both in product and process control. The economic impact of production variations is increasing dramatically and has led to rapid advancement in the field of characterisation of odours, off-taste and tainting. Taste is the ultimate measure of the quality of a food product. Industry has invested countless years identifying contaminants that detract from the unique taste of high profile products. There are only five major taste receptor types – bitter, sweet, sour, salty and umami. As opposed to the low hundreds of uniquely discriminated tastes, with typical character impact compounds such as 2,3-butanediol (“butter”) or isoamylacetate (“banana”), for odours this is in the order of the low thousands. Most of the odours are caused by organic volatile chemicals, rather than by particulates such as smoke or fog. Odorant molecules are typically hydrophobic and polar with molecular masses of up to about 300 Da. Gas chromatography has been, and still is, the instrumental method of choice for identifying the source of off-odour. In recent years, progress in sensor technology has enabled development of instruments (“electronic noses”, e-noses or EN) that can mimic the human sense of smell and provide low-cost and rapid sensory information. These instruments cannot identify the chemical compounds responsible for odour, but can compare samples and categorise them, after proper training. Input from a sensory panel is required and constitutes the link between instrumental methods and real practice. They can thus be used as quick screening tools or for monitoring air streams to detect the presence of chemical compounds.

2.4.1 Reason of odour problems in polymers:

(i) Out gassing of residual monomers, process solvents or chain transfer agents.

(ii) Low-MW oligomers, oils and waxes trapped in the polymer.

(iii) Thermal degradation of the polymer during processing, end-product manufacturing and use.

(iv) Additives with high vapour pressure (e.g. BHT and 2-hydroxy-4-octoxybenzophenone).

(v) degradation or interaction of additives in the polymer formulation.

(vi) volatiles produced during curing of thermosets, adhesives, sealants, etc.

(vii) radiation sterilisation of plastic packaging.

(viii) trace impurities.

(ix) chemical reactions with the environment (e.g. hydrolysis, oxidation); and

(x) external sources.

Table 1.1 Selected examples of active packaging systems

Active packaging system	Mechanisms	Food applications
Oxygen scavengers	Iron based Metal/acid Nylon MXD6 Metal (e.g. platinum) catalyst Ascorbate/metallic salts Enzyme based	Bread, cakes, cooked rice, biscuits, pizza, pasta, cheese, cured meats and fish, coffee, snack foods, dried foods and beverages
Carbon dioxide scavengers/emitters	Iron oxide/calcium hydroxide Ferrous carbonate/metal halide Calcium oxide/activated charcoal Ascorbate/sodium bicarbonate	Coffee, fresh meats and fish, nuts and other snack food products and sponge cakes
Ethylene scavengers	Potassium permanganate Activated carbon Activated clays/zeolites	Fruit, vegetables and other horticultural products
Preservative releasers	Organic acids Silver zeolite Spice and herb extracts BHA/BHT antioxidants Vitamin E antioxidant Chlorine dioxide/sulphur dioxide	Cereals, meats, fish, bread, cheese, snack foods, fruit and vegetables
Ethanol emitters	Encapsulated ethanol	Pizza crusts, cakes, bread, biscuits, fish and bakery products
Moisture absorbers	PVA blanket Activated clays and minerals Silica gel	Fish, meats, poultry, snack foods, cereals, dried foods, sandwiches, fruit and vegetables
Flavour/odour absorbers	Cellulose triacetate Acetylated paper Citric acid Ferrous salt/ascorbate Activated carbon/clays/zeolites	Fruit juices, fried snack foods, fish, cereals, poultry, dairy products and fruit
Temperature control packaging	Non-woven plastics Double-walled containers Hydrofluorocarbon gas Quicklime/water Ammonium nitrate/water Calcium chloride/water Super corroding alloys/salt water Potassium permanganate/glycerine	Ready meals, meats, fish, poultry and beverages
Temperature compensating films	Side chain crystallisable polymers	Fruit, vegetables and other horticultural products

2.4.2 Flavour/Odour Absorbers and Releasers:

The commercial use of flavour/odour absorbers and releasers is controversial due to concerns arising from their ability to mask natural spoilage reactions and hence mislead consumers about the condition of packaged food. For this reason, flavour/odour absorbers and releasers have been effectively banned in Europe and the USA. Nevertheless, flavour/odour absorbers and flavour-releasing films are commercially used in Japan and have a number of legitimate applications that cannot be easily dismissed. For example, in the USA, ScentSational Technologies has developed aroma-releasing packs that have been trialled by the US army to make ready-to-eat meals more appetising. Pira International Ltd estimated the global value of the flavour/odour absorber market in 2005 to be worth $46 million and has forecast this market in 2010 to be worth $68 million .

The interaction of packaging with food flavours and aromas has long been recognised, especially through the undesirable flavour scalping of desirable food components. For example, the scalping of a considerable proportion of desirable limonene has been demonstrated after only two weeks storage in aseptic packs of orange juice (Rooney, 1995). Commercially, very few active packaging techniques have been used selectively to remove undesirable flavours and taints, but many potential opportunities exist. An example of such an opportunity is the debittering of pasteurised orange juices. Some varieties of orange, such as Navel, are particularly prone to bitter flavours caused by limonin that is liberated into the juice after orange pressing and subsequent pasteurisation. Processes have been developed for debittering such juices by passing them through columns of cellulose triacetate or nylon beads. A possible active packaging solution would be to include limonin absorbers (e.g. cellulose triacetate or acetylated paper) into orange juice packaging material (Rooney, 1995). Two types of taints amenable to removal by active packaging are amines, which are formed from the breakdown of fish muscle proteins, and aldehydes, which are formed from the autoxidation of fats and oils. Unpleasant smelling volatile amines, such as trimethylamine, associated with fish protein breakdown, are alkaline and can be neutralised by various acidic compounds. In Japan, Anico Co. Ltd has marketed Anico bags that are made from film containing a ferrous salt and an organic acid such as citrate or ascorbate. These bags are claimed to oxidise amines as they are absorbed by the polymer film (Rooney, 1995).

Removal of aldehydes such as hexanal and heptanal from package headspaces is claimed by Dupont's Odour and Taste Control (OTC) technology that is based upon a molecular sieve with pore sizes of around 5 nanometres. Dupont claims that their OTC technology removes or neutralises aldehydes although evidence for this is lacking. The claimed food applications for this technology are snack foods, cereals, dairy products, fish, poultry and fish (Day, 2003). A similar claim of aldehyde removal has been reported by Swedish company EKA Noble, in collaboration with the Dutch company Akzo, who developed a range of synthetic aluminosilicate zeolites which they claim, absorb odorous gases within their highly porous structure. Their BMH™ powder can be incorporated into packaging materials, especially those that are paper-based, and apparently odorous aldehydes are absorbed in the pore interstices of the powder (Day, 2003).

Off-odour may be classified as a common type of **failure**. Base packaging material can itself contain solvent residues, either from coatings or, where the base packaging material is a laminate, from an adhesive. Such solvent residues can be ethyl acetate, toluene and THF, all of which have strong odours. Printing inks also often contain solvents with well-defined odours. A criterion for selection of a solvent for use in packaging manufacture, *e.g.* for printing inks, is a high odour threshold (OT) value (10-100 mg/m3). There are no generally agreed maximum levels for residual solvents in food packaging. The total level of residual solvents should preferably not exceed 30 mg/m3; for some of the more odorous solvents, such as isopropyl acetate, individual levels should be less than 5 mg/m3. Some types of packaging, particularly printed materials, can have detectable odours immediately after production but lose much of the odour during normal storage before use. Samples of such packaging should only be taken after the normal storage period. For substances of known chemical nature and origin, quantitative measurements can be carried out to confirm the cause of the odour. Where the off-odour is due to impurities, reaction products, or contaminants, the task of identification can be difficult. The standard definition of **taint** (ISO, 1992) is a taste or odour foreign to the product; off-flavours involve an internal deteriorative change. Common sources of taints and off-flavours may derive from direct contact (e.g. liquid packaging systems, pallets, cleaning materials), water and aerial contamination (e.g. flooring materials, paints, insulation materials), chemical or microbial reaction (e.g. autoxidation reactions). Examples of some common chemical taints are phenols in flooring materials, halophenols and anisoles in bleached paper/board materials, hydrocarbons (e.g. residual styrene monomer in PS), acrylates in UV-cured inks and varnishes, etc. Taints are derived from a wide variety of chemicals (phenols, halophenols, haloanisoles, sulphur containing compounds, alcohols, hydrocarbons, esters and ethers, amines, chlorinated hydrocarbons, carbonyl compounds, furans and oxygen-ring compounds, fatty acids, etc.).

Table 2 Potential odour problem related to additives types:

Additive(s)	Polymer(s)	Origin of odours
• *Initiators:*		
α-cumylperesters	PVC	Acetophenone
• *Chain-transfer agents:*		
Methyl ethyl ketone;	LDPE	Residual chain-transfer agents
Mercaptans, dodecanethiol	PMMA	
• *Plasticisers:*		
DEHP	PVC	Hydrolysis products (*e.g.* 2-ethylhexanol)
• *Pigments:*		
Cadmium red, orange, yellow; ultramarine blue	Various	Acidity (H_2S)
• *Stabilisers:*		
Thioesters	Polyolefins	Sulphoxide conversion products
Organotin mercaptides	PVC	Organotin mercaptides
Red phosphorous	PET, PC	Hydrolysis (phosphine)
Ba/Cd heat stabilisers	PVC	Free fatty acids, phenols, residual solvents
• *Lubricants:*		
ESBO	PVC	Oxidation
Ca/Zn stearates	HDPE	Thermal decompositon (aldehydes)
• *Slip agents:*		
Fatty acid amides	LDPE	Oxidation (aldehydes, nitriles)
Oleamide	LLDPE, LLDPE/LDPE	Degradation
Erucamide	LDPE	Degradation
• *Nucleating agents:*		
Bis-toluidine sorbitol	PP	Decomposition (4-methyl-benzaldehyde)
• *Cross-linking agents:*		
Dicumyl peroxide	XPE	Decomposition (acetophenone, cumyl alcohol, cumene, α-methyl styrene)
• *Blowing agents:*		
Azodicarbonamide	Various	Thermal degradation (NH_3, isocyanic acid)

2.5 Coated films:

Films are coated with other polymers or aluminium to improve the barrier properties or to import heat sealability. For example, nitrocellulose is coated on one side of cellulose film to provide a moisture barrier but to retain oxygen permeability. A nitrocellulose coating on both sides of the film improves the barrier to oxygen, moisture and odours and enables the film to be heat sealed when broad seals are used. A coating of vinyl chloride or vinyl acetate gives a stiffer film which has intermediate permeability. Sleeves of this material are tough, stretchable and permeable to air, smoke and moisture. They are used, for example, for packaging meats before smoking and cooking.

A thin coating of aluminium produces a very good barrier to oils, gases, moisture, odours and light. The properties are shown in Table 1.3

Film Type	Coating	Barriers to Moisture	Air/Odours	Strength	Clarity	Normal Thickness Micrometers
Cellulose	-	*	***	*	***	21 - 40
Cellulose	PVDC	***	***	*	***	19 - 42
Cellulose	Aluminium	***	***	*	-	21 - 42
Cellulose	Nitro-cellulose	***	***	*	-	21 - 24
Polythene (low density)	-	**	*	**	*	25 - 200
Polythene (high density)	-	***	**	***	*	350 - 1000
Polypropylene	-	***	*	***	***	20 - 40
Polypropylene	PVDC	***	***	***	***	18 - 34
Polypropylene	Aluminium	***	***	***	-	20 - 30
Polyester		**	**	***	**	12 -23
Polyester		***	***	***	**	-
Polyester		***	***	***	-	20 -30

2.6 Odour and flavor in food product:

The flavor of a food product is the integrated perception of a consumer using both the senses of smell and taste. Taste buds located on the tongue and in the back of the mouth enable a person to sense sweetness, sourness, saltiness, and bitterness. The tongue is also used to sense the physical texture of the food. Specialized cells of the olfactory epithelium within the nose are able to sense aroma volatiles. Together the human nose and tongue function together to assess and perceive the flavor of a product at the time of consumption.

Aromas are normally comprised of small molecules, light (< 300 Dal), polar and usually hydrophobic (Payne 1998). Simple aromas contain only one component. An example would be an alcohol. Complex aromas contain as many as hundreds of thousands of components. The commonly used example to demonstrate a complex aroma is coffee. Although coffee has a very distinct aroma, it is a complex with many components. The differences in aroma between different types of coffee are caused by subtle differences in components of a complex aroma (Payne 1998).

Aromas in the food industry, from raw ingredients to the final packaged product, are frequently important. These odors are currently monitored using sensory panel measurements and or through analytical techniques such as GC, GC/MS, and GC-olfactory. In recent years, electronic nose instrumentation has found expanded use as a complimentary tool to these techniques.

Off-odors and taints can arise in food products as a result of decomposition due to endogenous enzymes, microbial contamination, chemical oxidation, or other means of contamination (Hodgins and Simmonds 1995). Off-odors in food are one of the main reasons for consumer rejection of a product. One production run of a product with serious off-odors can result in damaged market sales as consumers may not only reject the product but also never try the product again.

Microbial contamination can produce sulfur volatiles, amines, and chloroanisoles that cause putrid, ammonia-like, musty odors in a number of products. Chemical oxidation and enzyme decomposition usually lead to a range of rancid-like off-odors. This is particularly true in food products with high lipid levels due to the formation of aldehydes and ketones (Hodgins and Simmonds 1995).

3. ADHESIVES AND INKS

3.1 General Terms(Related To Adhesives):

3.1.1 Adhesion: Adhesion is the process by which two surfaces are held together by interfacial forces (surface attraction) or mechanical interlocking.

3.1.2 Adhesive: An adhesive is a substance which is capable of holding materials together in a useful fashion by means of surface attraction. Surface attraction results from placing a thin layer of adhesive between two objects.

While many substances are capable of holding materials together, not all are useful. Molasses, for example, can be used to hold two pieces of wood together, but the joint can hardly be considered useful.

3.1.3 Bond Line: The bond line is the space or gap between two substrates which contains the adhesive.

3.1.4 Substrate: A substrate is a material which is held by an adhesive. Substrate is a generic term for the objects that are being bonded.

3.1.5 Surface: The surface of an object is that face of the object that is coated with an adhesive. Surfaces are usually not what they seem. A steel surface, for example, has layers of metal atoms beneath additional substances, which include metal oxides, an oxygen-hydrogen (OH) layer and water. An adhesive is actually applied to this water layer.

3.2 Adhesive Composition

The following terms relate to the composition of an adhesive.

3.2.1 Activators : Activators are chemicals which can be applied directly to a surface or `substrate or mixed with an adhesive to speed up the solidification of the adhesive. Activators are similar to both the curing agents and catalysts.

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3.2.2. Catalysts : Catalysts, also called accelerators, are chemicals which, when added Accelerators in small amounts, cause adhesives to solidify.

3.2.3 Curing Agents : A curing agent is a chemical which reacts with an adhesive polymer to cause it to solidify. Approximately equal amounts of adhesive resin and curing agent are mixed together to form a solid adhesive. Miscellaneous Some additional components that may be found in an adhesive include Components pigments, flame retardants, antifoam agents, and tougheners.

3.2.4 Plasticizers: A plasticizer is a chemical added to an adhesive to prevent it from becoming brittle. Many adhesive polymers are very strong, yet brittle enough to crack under impact. Plasticizers are added to soften the adhesive to keep it from becoming too brittle.

3.2.5 Polymers : Polymers are large chemicals composed of repetitive units. Polymers make up the largest portion of an adhesive.

3.2.6 Solvents: Solvents are liquids used to dissolve or suspend adhesives. Solvents are added to an adhesive formulation to make them fluid, allowing the adhesive to be spread or sprayed on a surface more easily. After the adhesive has been applied, the solvent evaporates during cure. Solvents are also used as thinners for some types of adhesives.

3.2.7 Tackifiers: A tackifier is a chemical which is added to an adhesive to make it "stickier". The tackifier holds the substrates together while curing is taking place. Not all adhesives contain tackifiers.

3.3 Adhesive Characteristics:

The following terms deal with the application and usable life of adhesives.

3.3.1 Cure : When an adhesive cures, it is converted from a liquid to a solid state.

The curing process may be accomplished by cooling, loss of solvents, or internal chemical reaction. Curing generally implies some type of physical or chemical change in the adhesive, while hardening or melting is reversible. Green Strength The green strength is a measure of the ability of the adhesive to support a load during the green time.

3.3.2 Green Time : Green time is the time between application and solidification of the (Open Time) adhesive. During the green time, it is still possible to position parts.

3.3.3 Fixturing time : (the amount of time before bonded parts can be handled) is often somewhat longer than green time. Kickover is the sudden increase in viscosity which accompanies the curing of an adhesive. Once an adhesive "kicks over", it is almost in its solid state and can no longer be easily spread.

3.3.4 Pot Life: The pot life of an adhesive is the length of time it remains usable for mixing . Pot life is usually an important factor only with adhesives that are mixed together and begin curing almost immediately.

3.3.5 Rheology: Rheology is the ability of a material to flow and deform. Adhesives with good rheology flow easily and break cleanly at the end of a bead.

3.3.6 Shelf Life: Shelf life is the usable storage time of a material. Most adhesives have a shelf life of 6 to 12 months. The shelf life of an adhesive may be increased by refrigeration, and is usually shortened by exposure to heat.

3.3.7 Viscosity : Viscosity is the resistance to flow or degree of thickening of a fluid. Some adhesives flow very easily, whereas other types of adhesives are so thick they hardly flow at all. Water and thick putties represent the extremes of viscosity.

3.3.8 Wetting : Wetting is intimate contact of a liquid and a surface. Good wetting is only possible if there is good attraction between the surface and the liquid. Proper wetting of a mating surface is essential for good bonding.

CLASSIFICATION OF ADHESIVES:

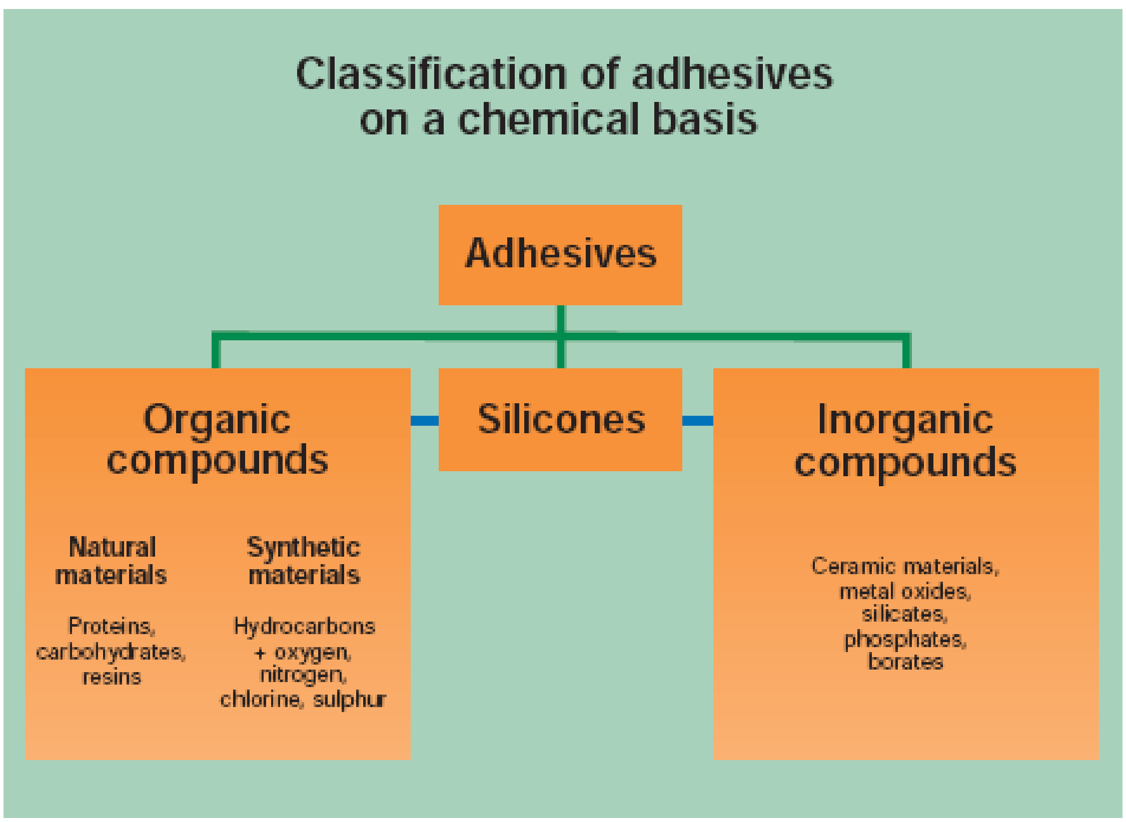


Figure- 1 Classification Of Adhesives on chemical basis

The Classification of adhesives can be done by several ways, some of them from practical point of views are as follows: -

3.4 Classification Of Adhesive On Application basis

According to the application(in which form adhesive applied to the substrate)adhesive can be classified as follows:

3.4.1 Natural Adhesives:

(a) Starch and dextrin

These materials are derived from cereals or roots such as corn, wheat, tapioca, sogo, etc. The basic constituent is polysaccharide which on hydrolysis yields long chain glucose units. Variations can occur with the use of different food materials and with changes in hydrolysis methods.

The main use for these adhesives is the paper industry where they are used in multiwall bags, corrugated paper etc. Dextrin which is dry roasted starch is used in remoisten able adhesives.

(b) Gelatine (animal, fish, vegetable glues)

There is a wide range of products included in this overall category. Generally they are all proteins which are derived from the hydrolysis of either collagen or soya flour, or by separating casein from skim milk.

• Animal glues from bones and hides are used in gummed tape, textiles and the paper industry such as book-binding and case making.

• Fish glues manufactured from skins have been used in rubber gasket to steel bonding, paper to steel etc.

• Caseirs from skim milk are used mainly in wood to wood bonds.

• Soya bean glues are used in paper backs.

• Blood glues are mainly used in veneering and plywood.

(c) Asphalt and Bitumin

These high fractions of crude oil are more used as sealers rather than adhesives except in the bonding of coarse grade papers to produce waterproof building papers.

(d) Natural rubber

Rubber is derived as a latex from the rubber tree (*Hevea brasiliensis*). The raw latex is collected and concentrated and either sold as a latex or coagulated and sold as solid for solvent dissolution. Adhesives made from natural rubber, which is essentially polyisoprene, are very tacky and are used in pressure sensitive applications or where long bond times and tack are required such as tapes, ceramic tile adhesives, flooring adhesives etc.

(e) Resins, Shellac

Natural resins have been used as adhesives. Shellac is used in bonding mica splittings to form mica board and used to be used in abrasives. Gum arabic is used in remoisten able adhesives. Copal gums are used in spirit soluble lino cements.

3.4.2 Drying adhesives :

These adhesives are a mixture of ingredients (typically polymers) dissolved in a solvent. Glues and rubber cements are members of the drying adhesive family. As the solvent evaporates, the adhesive hardens. Depending on the chemical composition of the adhesive, they will adhere to different materials to greater or lesser degrees. These adhesives are typically weak and are used for household applications. Some intended for small children are now made non-toxic.

Figure 2 glue gun, an example of a hot adhesive

3.4.3 Hot adhesives (thermoplastic adhesives)

They also known as "hot melt" adhesives, these adhesives are thermoplastics; they are applied hot and simply allowed to harden as they cool. These adhesives have become popular for crafts because of their ease of use and the wide range of common materials to which they can adhere. A glue gun, pictured right, is one method of applying a hot adhesive. The glue gun melts the solid adhesive and then allows the liquid to pass through the "barrel" of the gun onto the material where it solidifies.

3.4.4 Reactive adhesives:

Reactive adhesives are generally thermosetting plastics. Epoxy resins are the most common example of this kind of adhesive. Reactive adhesives generally come in two separate containers. The two ingredients of the adhesive must be mixed in certain proportions immediately before application. Generally one ingredient is a monomer, or resin, and the second is a reaction initialiser. When the two are mixed together, a polymerisation reaction occurs which solidifies the adhesive.

Reaction adhesives may also react with the surface of the materials to be stuck together. This process is called bonding, in which the adhesive forms chemical bonds with the material, and is distinct from sticking, the action of common glues.

A special case of this kind of adhesive is cyanoacrylate (more commonly known by the brand name "super glue") which reacts with trace moisture on the surfaces being bonded and therefore does not need any mixing before application.

Reactive adhesives are very strong and are used for high-stress applications such as attaching wings to aircraft. Because the strength of a reactive adhesive is a result of chemical bonding with the surface material, reactive adhesives are applied in thin films. Reactive adhesives are less effective when there is a secondary goal of filling gaps between the surfaces.

Such adhesives are frequently used to prevent loosening of bolts and screws in rapidly moving assemblies, such as automobile engines. They are largely responsible for the quieter running modern car engines.

3.4.5 Pressure sensitive adhesives

In order to form a permanent bond, structural adhesives harden via processes such as evaporation of solvent or water (white glue), reaction with radiation (dental adhesives), chemical reaction (two part epoxy), or cooling (hot melt), as described above. In contrast, pressure sensitive adhesives (PSAs) form a bond simply by the application of light pressure to marry the adhesive with the adherend. Pressure sensitive adhesives are designed with a balance between flow and resistance to flow. The bond forms because the adhesive is soft enough to flow, or wet, the adherend. The bond has strength because the adhesive is hard enough to resist flow when stress is applied to the bond. Once the adheisve and the adherend are in close proximity, there are also molecular interactions such as vander Waals forces involved in the bond. These contribute significantly to the ultimate bond strength.

Pressure sensitive adhesives (PSAs) are designed for either permanent or removable applications. Examples of permanent applications include safety labels for power equipment, automotive interior trim assembly, and sound/vibration damping films. Some high performance permanent PSAs exhibit high adhesion values and can support kilograms of weight per square centimeter of contact area, even at elevated temperature. Permanent PSAs may be initially removable (for example to recover mislabeled goods) and build adhesion to a permanent bond after several hours or days.

Removable adhesives are designed to form a temporary bond, and ideally can be removed after months or years without leaving residue on the adherend. Removable adhesives are used in applications such as surface protection films, masking tapes, bookmark and note papers, price marking labels, promotional graphics materials, and for skin contact (wound care dressings, EKG electrodes, athletic tape, analgesic and transdermal drug patches, etc.). Some removable adhesives are designed to repeatedly stick and unstick. They have low adhesion and generally can not support much weight.

Pressure sensitive adhesives are manufactured with either a liquid carrier or in 100% solid form. Articles are made from liquid PSAs by coating the adhesive and drying off the solvent or water carrier. They may be further heated to initate a crosslinking reaction and increase molecular weight. 100% solid PSAs may be low viscosity polymers that are coated and then reacted with radiation to increase molecular weight and form the adheisve; or they may be high viscosity materials that are heated to reduce viscosity enough to allow coating, and then cooled to their final form.

3.5 Adhesive Classification On Structural Basis:

All Adhesives contain a binder, which provides toughness and cohesive strength. The chemical make up of this binder gives the most important properties of the adhesives like bond strength and tackiness etc.

Structural or Performance Adhesives are load-bearing adhesives. That is, they add strength to the products being bonded. Structural adhesives are used to build products as varied as office furniture, boats, and automobiles. There are approximately ten adhesive families commonly referred to as structural adhesives:

Acrylic, Anaerobic, Cyanoacrylate, Epoxy, Hot Melt, Methacrylate, Phenolic, Polyurethane, Solvent Cement and Tapes. The seven most commonly used are:

- Acrylic
- Anaerobic
- Cyanoacrylate
- Epoxy
- Hot Melt
- Methacrylate
- Polyurethane

3.5.1 Acrylic Adhesives:

Acrylic Adhesives have formulations that tolerate dirtier and less prepared surfaces generally associated with metals. They challenge epoxies in shear strength, and offer flexible bonds with good peel and impact resistance. Acrylics are two-part adhesives, the resin is applied to one surface and an accelerator or primer to the other. The two parts can be pre-applied and later mated. Once mated, handling strength is typically achieved in a few minutes. Curing can be completed at room temperature. Newer formulations of acrylics are now available in mix-in formulations. Anaerobic Adhesives are one of the most easily applied structural adhesives. Because the curing mechanism is triggered by deprivation of oxygen (hence the name “anaerobic”, or “without air”), anaerobic adhesives will not cure prematurely. These adhesives are based on acrylic polyester resins and are produced in viscosities ranging from thin liquids to viscous thixotropic pastes. Although they have high cohesive strength, they have low adhesive strength and are not suited to permeable materials. Anaerobics do not fill gaps well and may require primers. They are generally used as thread fasteners (i.e. Henkel Omnifit).

3.5.2 Cyanoacrylate Adhesives (Crazy Glue or Super Glue):

Cyanoacrylate Adhesives are also easily applied and offer extremely fast cure rates. Cyanoacrylates are relatively low viscosity fluids based on acrylic monomers and, when placed between closely fitting surfaces, some will cure to a strong joint in two to three seconds. Cyanoacrylates' ability to bond plastics and rubbers to themselves or to other substrates are their biggest advantage. On the other hand, cyanoacrylate adhesives exhibit poor impact resistance, are vulnerable to moisture and solvents, and are suitable only for bonding small areas. In addition, they do not fill gaps well, require precise mating of bonded surfaces, and are relatively expensive. They also have poor solvent and water resistance.

3.5.3 Epoxy Adhesives:

Epoxy Adhesive have been available longer than any other engineering adhesive and are the most widely used structural adhesive. Epoxy adhesives are thermosetting resins which solidify by polymerization and, once set, will soften but not melt on heating. Two-part resin/hardener systems will solidify on mixing (sometimes accelerated by heat), while one-part materials require heat to initiate the reaction of a latent catalyst. Epoxies offer very high shear strengths, and can be modified to meet a wide variety of bonding needs. Generally, epoxy bonds are rigid; they fill gaps well with little shrinkage.

3.5.4 Hotmelts:

Hot Melts are various polymers can be used as hotmelts. In a heated state the polymers are liquid, and can hence be processed, but on cooling they solidify. Hotmelts used by industry can be in the form of blocks, rods, granulate, powder and film at room temperature. They are applied to the substrate surface as a melt. The adhesive is applied by rolling or spraying and joining is carried out immediately after application or after reheating the solidified layer. Alternatively the solid adhesive can be laid on the substrate as a film or net and then hot-pressed. In general the joining step requires the application of pressure. A feature of hotmelts is that on cooling they very rapidly build up their internal strength. A natural hotmelt familiar to everyone is beeswax which bees use as a building material Bond strengths between 15 and 35 MPa can be achieved with industrial hotmelts. They do however have a tendency to undergo creep when subjected to continuous stress or high temperatures. On the plus side, these adhesives can be used to create thermally detachable and also redetachable bonded joints due to their thermoplastic structure. The bonded joint must however not be heated up to its melting temperature range because the adhesive loses strength at considerably lower temperatures in the so-called “softening region”. The processing temperature can be varied within a certain range and depends on the desired viscosity of the adhesive for the particular application. The viscosity of the melt determines the application properties of the adhesive. In general a low viscosity facilitates wetting. Hotmelts are used in industry for a wide range of applications. The packaging industry (manufacture of packaging from paper, cardboard and sheet metal) is one of the major users. Hotmelts are also used in the printing industry for bonding the spines of books, in the textile industry for bonding appliqué and in the shoe-making industry for bonding for example shoe soles. The wood processing industry uses hotmelts for veneer surrounds and edging. The car manufacturing industry employs hotmelts for a host of applications including bonding insulating and cushioning materials, bonding headlight covers into metal frames and for wheel covers. The electronics industry also uses hotmelts, for example for bonding coil windings and coil ends.

3.5.5 Methacrylate :

Methacrylate Adhesives provide a unique balance of high tensile, shear, and peel strengths with the maximum resistance to shock, stress, and impact across a wide temperature range. Methacrylates can generally be used without surface preparation when joining plastics or metals. They are two-component reactive materials based on methyl methacrylate monomer that, when mixed together, have a controlled cure speed based on the appropriate application process. Methacrylates are tolerant to off-ratio mixing and remain strong and durable under severe environmental conditions. They resist water and solvents to form an impenetrable bond.

3.5.6 Polyurethane Adhesives:

Polyurethane Adhesives are named after the polymer type formed on completion of the reaction. The adhesives are usually two-component, one side is always isocyanate based, the other formulated from one of several co reactants often amines or glycols. They are known for toughness and flexibility even at low temperatures. They have fairly good shear strength and excellent water and humidity resistance.

3.6 Adhesive Classification On Component Basis

a)One Component Adhesive

These are available in one component solution, hot melt or emulsion form and applied directly to the substrate to make bond.

b)Two Component Adhesive

These are available in two separate components in the form of solution or emulsion. Pre mixing of these two components is required before applying to the substrate. They have good performance but their pot life is very less.

3.7 PRINTING INK TECHNOLOGY AND MANUFACTURE

Printing is widely used in our society to pass on information and to decorate objects. This has resulted in printing being used on many different surfaces ranging from aluminium cans and plastic bottles through to paper. Special inks have been developed for use in these different situations.

Printing inks are made of four basic components:

• **Pigments** – These are to colour the ink and make it opaque.

• **Resins** - Which bind the ink together into a film and bind it to the printed surface.

• **Solvents** - To make the ink flow so that it can be transferred to the printing surface.

• **Additives -** Which alter the physical properties of the ink to suit different situations .

These are formulated into ink in a two step process.

Step 1 - Varnish manufacture
Varnish is the clear liquid that is the base of any ink. Different varnishes are made for different inks, but they are all made by mixing the resins, solvents and additives (often at high temperatures) to form a homogeneous mixture. The resins react together to some extent to make larger molecules, making the varnish more viscous the longer these reactions are allowed to occur.

Step 2 - Pigment dispersal
The pigment is mixed into the varnish and then ground to break up clumps of pigment and to spread the pigment evenly through the ink.

3.7.1 RAW MATERIALS:

As has already been stated, the raw materials for ink production are pigments, binders, solvents and additives. In New Zealand, the ink manufacturer buys these materials either locally or overseas, and blends and reacts them to make ink. These materials are discussed below.

Pigments
The most obvious role of a pigment is to colour the ink. However, they can also provide gloss, abrasiveness and resistance to attack by light, heat, solvents etc. Special pigments

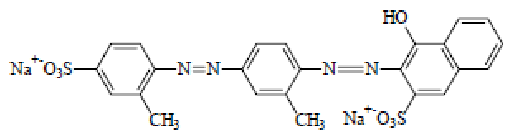
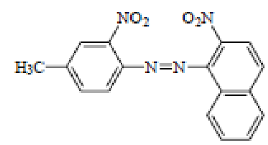
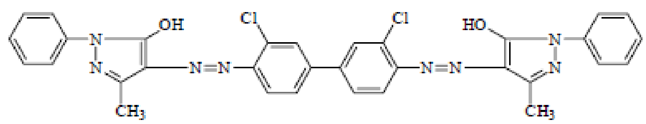
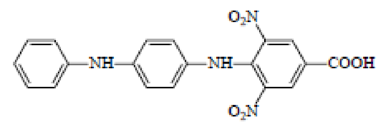
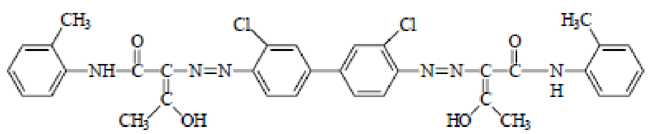
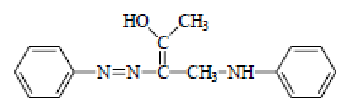
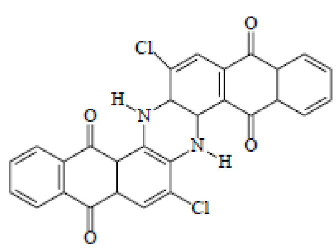
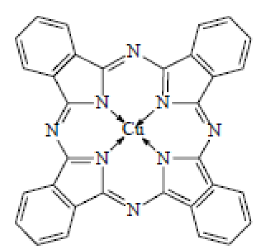
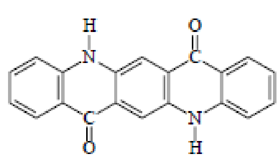
known as extenders and opacifiers are also used. Extenders are transparent pigments which make the colours of other pigments appear less intense, while opacifiers are white pigments which make the paint opaque so that the surface below the paint cannot be seen. Common pigments used in the manufacture of printing inks are listed in Table 4.

Resins

Resins are primarily binders - they bind the other ingredients of the ink together so that it forms a film and they bind the ink to the paper. They also contribute to such properties as gloss and resistance to heat, chemicals and water. Many different resins are used, and typically more than one resin is used in a given ink. The most commonly used resins are listed below:

- Acrylics
- Alkyds
- Cellulose derivatives
- Rubber resins
- Phenolics
- Ketones
- Maleics
- Formaldehydes

Table-4 Common printing ink pigments

Class	Examples	
Inorganic white (opacifiers)	Titanium dioxide (TiO_2) - in either rutile or anatase form	Zinc oxide (ZnO)
Extenders	Calcium carbonate ($CaCO_3$)	Talc - mixed oxides of magnesium, calcium, silica and aluminium
Inorganic black	Carbon black	
Organic red	 Lithol (C.I. 26670[3])	 Toluidine derivative (C.I. 12120)
Organic orange	 Pyrazolone (C.I. 21110)	 Dinitroaniline (C.I. 10390)
Organic yellow	 A di azo pigment (C.I. 21095)	 Hansa yellow (C.I. 11660 derivative)
Organic green	Phthalocyanine green	PMTA
Organic blue	 Indanthrene (C.I. 69825)	 Phthalocyanine blue (C.I. 74160)
Organic violet	 $-Quinacridone (C.I. 46500)	Dioxazine or Benzimidazolone

Solvents

Solvents are used to keep the ink liquid from when it is applied to the printing plate or cylinder until when it has been transferred to the surface to be printed. At this point the solvent must separate from the body of the ink to allow the image to dry and bind to the surface. Some printing processes (e.g. the gravure5 and flexographic6 processes) require a solvent that evaporates rapidly. These use volatile solvents (i.e. those with boiling points below 120^{o}C) such as those listed in Table 5.

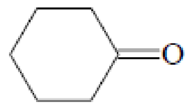
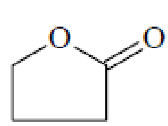
Table-5 Volatile printing ink solvents

Name	Structure or composition	Boiling point / ^{o}C
methylated spirits		
ethyl acetate	$CH_3COOCH_2CH_3$	77
isopropanol	$CH_3CHOHCH_3$	82.5
n-propyl acetate	$CH_3COOCH_2CH_2CH_3$	101.6

High-boiling point (T_b = 240 - 320_{o}C) hydrocarbons are chosen as solvents for lithographic inks as the solvent used must be viscous and hydrophobic.

Screenprinting inks need to have solvents with moderately high boiling points. Some commonly used solvents are listed in Table 6.

Table 6 - Some solvents used in printing inks

Name	Structure or composition	Boiling point / °C
Cyclohexanone		155.6
Butoxyethanol	$HOCH_2CH_2O(CH_2)_3CH_3$	171 - 172
Aromatic distillates	mixture of compounds chosen by boiling point	240 - 290
Butyrolactone		b.p.$_{12}$[7] = 89
Methoxypropanol acetate		

Additives

Many different types of additives are used to alter the final properties of the paint. The most common types of additives (with typical examples) are listed in table 6.

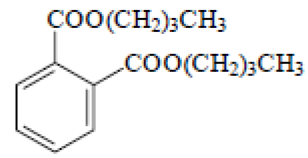
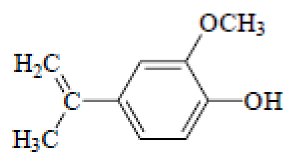
Type	Function	Typical example
Plasticiser	Enhances the flexibility of the printed film	 dibutyl phthalate
Wax	Promotes rub resistance	Carnauba - an exudate from the leaves of *Copernicia prunifera*. Consists of esters of hydroxylated unsaturated fatty acids with at least twelve carbon atoms in the acid chain.
Drier	Catalyses the oxidation reaction of inks which dry by oxidation	salts or soaps of cobalt, manganese or zirconium
Chelating agent	Increases the viscosity of the ink (aluminium chelate) and promotes adhesion (titanium chelate)	
Antioxidant	Delays the onset of oxidation polymerisation by reacting with free radicals formed during the autooxidation thus preventing them from reacting further	 eugenol
Surfactants[10]	Improves wetting of either the pigment or the substrate	
Alkali	Controls the viscosity / solubility of acrylic resins in water based inks	$HOCH_2CH_2NH_2$ monoethanolamine
Defoamer	Reduces the surface tension in water based inks, meaning that stable bubbles cannot exist	hydrocarbon emulsions

Table-6 Common classes of printing ink additives

3.8 COMPOSITION OF INKS

The compositions of inks used in different situation are shown in following tables-

Table 7 - Letterpress ink for newspaper

Ingredient	Function	Amount / % w/w
carbon black	black pigment	13.00
9 poise mineral oil	used instead of varnish as a wetting agent	68.00
0.5 poise mineral oil	used instead of varnish as a wetting agent	10.00
asphaltum solution		5.00
280 - 320°C petroleum distillate	solvent	2.00

Table-8 Lithographic ink for paper

Ingredient	Function	Amount / % w/w
organic pigment	coloured pigment	18.00
quickset varnish		40.00
gloss varnish		15.00
fast setting varnish		15.00
polyethylene wax paste	prevents damage to the ink film from rubbing	5.00
anti set-off paste		3.00
cobalt / manganese driers	catalyses drying oil oxidation	1.00
280 - 320°C petroleum distillate	high boiling point solvent	3.00

Table 9 - Flexographic ink for polyethylene film

Ingredient	Function	Amount / %w/w
titanium dioxide	white pigment and opacifier	35.00
alcohol soluble nitrocellulose	resin	5.00
alcohol soluble polyamide	resin	15.00
dibutyl phthalate	plasticiser	1.00
polyethylene wax	prevents damage to the ink film from rubbing	1.00
amide wax	prevents damage to the ink film from rubbing	1.00
ethanol	low boiling point solvent	30.00
n-propyl acetate	low boiling point solvent	8.00
n-propanol	low boiling point solvent	4.00

Table 10 - Gravure ink for paper

Ingredient	Function	Amount / %w/w
C.I. pigment red 57:1	red pigment	10.00
alcohol soluble nitrocellulose	resin	20.00
ketone resin	resin	10.00
dioctyl phthlalate	plasticiser	2.00
polyethylene wax	prevents damage to the ink film from rubbing	1.00
ethanol	low boiling point solvent	30.00
n-propyl acetate	low boiling point solvent	20.00
ethoxy propanol	low boiling point solvent	7.00

3.9 Ink drying and curing:

After the ink has been applied to the surface to be printed it must bind there to ensure it stays. This can happen simply as a result of the ink drying, or can take place in a series of crosslinking and polymerisation reactions that form a film and to bind it to the printed surface. These reactions are known as curing reactions. Ink drying and curing can happen *via.* Any one (or a combination) of the following processes:

3.8.1 Oxidation. If drying oil is present in the solvent, it will react with oxygen in the atmosphere and undergo curing reactions.

3.8.2 Evaporation. Some inks, usually those used in applications where speed is important, are designed to dry and cure as the solvent evaporates off. Volatile solvents such as methylated spirits are usually used, but solvents with boiling points above 120$_o$C are used for screen-printing inks to prevent the ink from drying during application.

3.8.3 Penetration. Inks that are printing on porous surfaces are sometimes designed so that the solvent penetrates into the bulk of the printing surface, leaving dry ink on the surface.

3.8.4 Radiation curing. Radiation (usually U.V.) is fired at the ink, instigating a series of polymerisation reactions. Most of the inks that cure this way are water-based.

3.8.5 Precipitation. Excess water (usually in the form of steam) is added to an ink system that is only sparingly miscible in water. The sudden increase in diluent concentration causes the solubility of the resin to decrease sharply and the resin precipitates onto the printed surface. The excess water evaporates off.

CHAPTER 3 EXPERIMENTATION

First of all collected the samples of packaging films from the different units of processing plants and note down their trade name and specification. The samples were collected on the basis of their market consumption and that were of different base materials.

S.N	TRADE NAME	WORK ORDER	STRUCTURE	PRINTING
1	Hot & Tasty (Double layer)	EN3645PR1	620mm × 12 (PET) plain, 625mm × 60 μ (PE) film	Reverse
2	Armato Twiggles (Double layer)	EN3591	1115mm ×17μ OP(BOPP Film), 1110 × 17 (BOPP Film) MT(MET	Reverse
3	Sundrop (Double layer)	DN258PR1	1020mm ×15 μ oriented nylon, 1020 × 90μ polywhite	Reverse
4	Vico vajradanti (Monolayer)	DM38SR1	575mm × 40 μ PVC (Shrink)	Reverse
5	Wipro baby soft (Monolayer)	DB67PR1	615 × 75 (PE film)NT (Natural)	Surface

Table-11(samples structure)

In this way total eight samples were collected and GC(Gas Chromatography) and Jar odour test were performed to know the solvent retention and intensity of odour respectively.

S.N	TRADE NAME	INK GSM	ADHESIVE GSM	INK USED	ADHESIVE USED	TYPE OF LAMINATION
1	Hot & Tasty (Double layer)	1.0	2.6	DIC (PU based, Toluene free)	2511	Solvent base
2	Armato Twiggles (Double layer)	0.4	1.6	DIC (PU based, Toluene free)	7729/6029	Solvent less
3	Sundrop (Double layer)	1.5	2.2	FCL (PVC ink)	2511	Solvent base
4	Vico vajradanti (Monolayer)	2.0	0	FCL (PU based)	-	-
5	Wipro baby soft (Monolayer)	1.0	0	Siegwerk	-	-

Table-12(Ink & Adhesive property)

4.1 Gas Chromatography:

Gas chromatography (GC), is a common type of chromatography used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition. Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture (the relative amounts of such components can also be determined). In some situations, GC may help in identifying a compound. In preparative chromatography, GC can be used to prepare pure compounds from a mixture.

In gas chromatography, the mobile phase (or "moving phase") is a carrier gas, usually an inert gas such as helium or an unreactive gas such as nitrogen. The stationary phase is a microscopic layer of liquid or polymer on an inert solid support, inside a piece of glass or metal tubing called a column (an homage to the fractionating column used in distillation). The instrument used to perform gas chromatography is called a gas chromatograph (or "aerograph", "gas separator").

The gaseous compounds being analyzed interact with the walls of the column, which is coated with different stationary phases. This causes each compound to elute at a different time, known as the retention time of the compound. The comparison of retention times is what gives GC its analytical usefulness.

Gas chromatography is in principle similar to column chromatography (as well as other forms of chromatography, such as HPLC, TLC), but has several notable differences. Firstly, the process of separating the compounds in a mixture is carried out between a liquid stationary phase and a gas mobile phase, whereas in column chromatography the stationary phase is a solid and the mobile phase is a liquid. (Hence the full name of the procedure is "Gas–liquid chromatography", referring to the mobile and stationary phases, respectively.) Secondly, the column through which the gas phase passes is located in an oven where the temperature of the gas can be controlled, whereas column chromatography (typically) has no such temperature control. Thirdly, the concentration of a compound in the gas phase is solely a function of the vapor pressure of the gas.

4.1.1 Theory:

A **gas chromatograph** is a chemical analysis instrument for separating chemicals in a complex sample. A gas chromatograph uses a flow-through narrow tube known as the column, through which different chemical constituents of a sample pass in a gas stream (carrier gas, mobile phase) at different rates depending on their various chemical and physical properties and their interaction with a specific column filling, called the stationary phase. As the chemicals exit the end of the column, they are detected and identified electronically. The function of the stationary phase in the column is to separate different components, causing each one to exit the column at a different time (retention time). Other parameters that can be used to alter the order or time of retention are the carrier gas flow rate, column length and the temperature.

In a GC analysis, a known volume of gaseous or liquid analyte is injected into the "entrance" (head) of the column, usually using a microsyringe (or, solid phase microextraction fibers, or a gas source switching system). As the carrier gas sweeps the analyte molecules through the column, this motion is inhibited by the adsorption of the analyte molecules either onto the column walls or onto packing materials in the column. The rate at which the molecules progress along the column depends on the strength of adsorption, which in turn depends on the type of molecule and on the stationary phase materials. Since each type of molecule has a different rate of progression, the various components of the analyte mixture are separated as they progress along the column and reach the end of the column at different times (retention time). A detector is used to monitor the outlet stream from the column; thus, the time at which each component reaches the outlet and the amount of that component can be determined. Generally, substances are identified (qualitatively) by the order in which they emerge (elute) from the column and by the retention time of the analyte in the column.

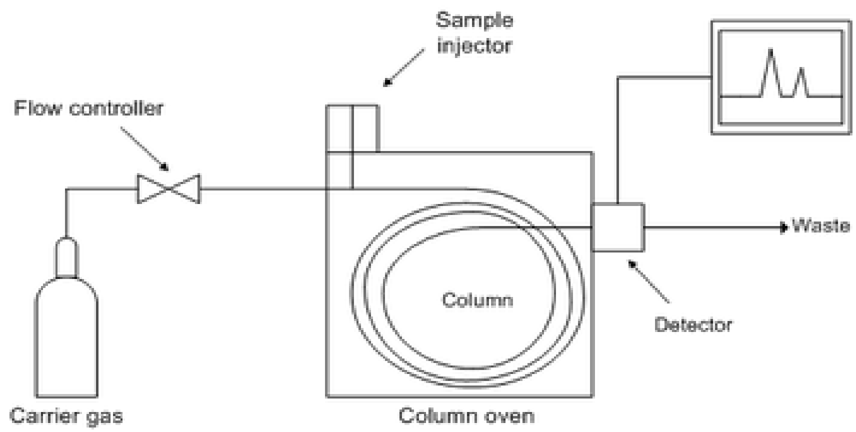


Figure-2 Gas Chromatograph

4.1.2 Analytical Condition:

a) Column: Elite-5 (Crossbond 5%diphenyl-95% dimethyl polysiloxane) 30 meter, 0.25mm ID, 0.25µm df.

b) Carrier gas: Nitrogen (Pressure to be set 5-6 kg/cm^2 on cylinder.

c) Flow: 1ml/min

4.1.3 GC Parameter: Oven temperature 40°C, hold for 8 minutes, rate 15°C/min up to 100°C, 25°C/min up to 250°C.

Injector	**-**	200°C
Detector	**-**	260°C
Attenuation	**-**	2
Range	**-**	1

a) **Flow:**

Hydrogen	-	40ml/min
Air	-	400ml/min

Split	-	10ml/min

b) Parameter onTurbomatrix 16 Headspace sampler:

Oven Temperaure	-	60
Needle Temperature	-	100
Transfer Line Temperature	-	110
Thermostate Time	-	20 min
Pressurization Time	-	1 min
GC Cycle	-	30 min

c) Standard solution preparation:

- Take 100 ml HPLC water & add 5µl 0f EA, MEK, TOLUENE, IPA, MIBK, NPAc, NPA, ETHANOL, NBA, BUTYL CELLOSOLVE etc.
- Take 10 ml of above solution & add another 40 ml HPLC water.
- Take 5ml of this as a standard mixture.

d) Instrument setting:

- Open nitrogen, hydrogen & zero air in the same sequence.
- Switch on the computer.
- Switch on the main GC & Head space then wait till all parameter reach their set marks.
- Ignite flame by touching FID panel.
- Click software icon (TCNav) & enter analyst name.
- Switch on Turbomatrix headspace sampler.

- Open sequence, select the sequence, name the sample with required method as well as data.
- Give the set up with respective sequence number.
- Wait all parameter transferred from software to GC.(within 1 min, main GC equilibrate with software and shows ready signal on main window. This shows that our GC is ready for sample testing.)

e) Instrument Setting (Head Space):

- Place sample vial in head space sampler & mentioned their vial number on HS panel.
- Start the run & wait, till run is complete.

f) Detectors

A number of detectors are used in gas chromatography. The most common are the Flame ionization detector (FID) and the thermal conductivity detector (TCD). While TCDs are essentially universal and can be used to detect any component other than the carrier gas (as long as their thermal conductivities are different than that of the carrier gas, at detector temperature), FIDs are sensitive primarily to hydrocarbons, and are more sensitive to them than TCD. Both detectors are also quite robust. Since TCD is non-destructive, it can be operated in-series before an FID (destructive), thus providing complementary detection of the same eluents.

4.2 Jar Odour Test:

4.2.1: Definitions:

Odour: Sensory attributes perceptible by one's olfactory organ on sniffing certain volatile substances.

Off- flavor: A typical flavor of food stuff, often associated with the deterioration of the food stuff or due to external sources of contamination (packaging materials, promotional items, storage, transportation, oxidation etc.)

4.2.2 Principle of the method: A defined quantity of packaging or other food contact material is placed in an odour free glass jar and incubated for one hour at 40°C. A packaging sensory panel evaluates the odour released on scale from 0 (no perceptible odour) until 4-5 (strong odour) in comparison to an empty jar taken as references. The limit of acceptability is a median score ≤ 2.5 i.e between weak and clean odour.

4.2.3 Materials:

- Air circulation oven adjustable up to 100°C.
- Measuring device for calculating 6 dm^2 (ruler, 6 dm^2 metal template).
- Cutting device (cutter, scissor).
- 1 litre glass jar, with glass lid, odourless , Teflon gasket and removable metallic clips .

4.2.4 Glassware cleaning and decontamination:

All equipments used shall be free from odour and only in use for sensory analysis. Use only minimum odour cleaning agents for cleaning. Care is needed to ensure that lids, seals and inserts do not become a source of odour. The 1 litre jar must thoroughly washed and dried at high temperature (100^{o}C) before use.

4.2.5 storage of packaging materials samples:

Prior to conduct the test, preserve the packaging materials under cold condition (at approximately 5^{o}C in a refrigerator) and wrapped in an uncoated sheet of aluminium foil or in an airtight glass container.

The packaging material samples must be representatives of the whole material and production. For sheet or film type materials, sample representative material specimens and eliminates the outer layers (e.g initial layers of a roll, first and last sheets of a pile.)

4.2.6 Test condition:

For flexible laminated, single or multilayered materials, the material surface is 6dm^2 (600cm^2). This corresponds to an area/container volume ratio of 6dm^2/l. In the case of printed material care should be taken to maintain about the same ratio between the printed an unprinted surfaces in the section to be tested.

4.2.7 Method:

The number of jars to prepare for each test material depends on the size of the panel (one jar for three panel members, two jars for six panel members).

Insert into each container the appropriate surface area of packaging materials. The jars are hermetically closed with the odourless teflon gasket by fixing the lid with three removable metallic clips.

After heating the samples, the jars still have to be prepared for use by the sensory panel. For this purpose, a weight of ca. 1 kg is placed on the top of the jar to hold down the lid for tightness. Then the clips are removed. The panel members opens the jars by lifting the weight and lid and then sniff its content. It is possible to not use the weight, if each panel member pays attention to carefully replace the lid on the jar after sniffing, and if the whole test is carried out within a short period of time. If there is a visual differences make sure that the material placed in the container is not visible from the outside (e.g. cover the container with aluminium foil).

4.2.8 Rating:

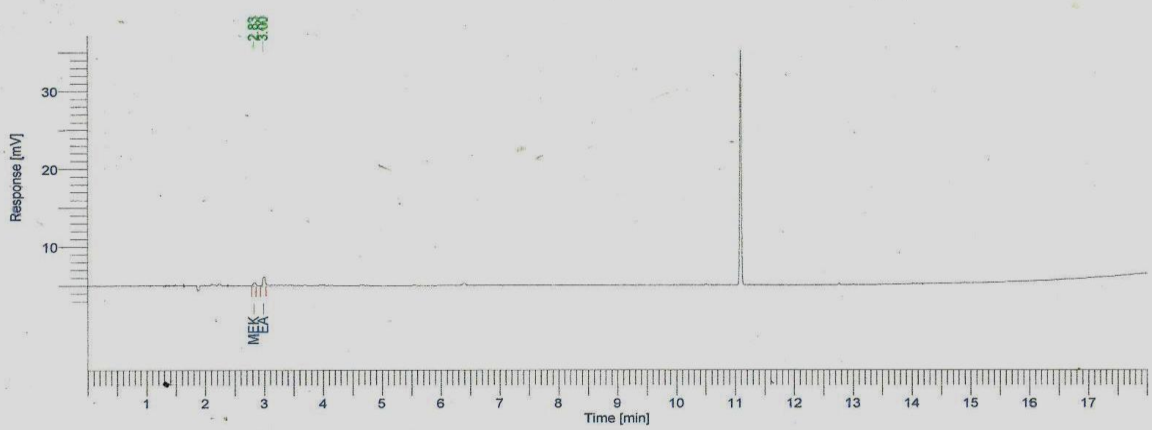
Rating Level	Description
1	Essentially no odour (Blank jar smell)
2-3	Slight odour (Not objectionable)
4	Noticeable odour (Borderline acceptable)
5-7	Appreciable odour (Objectionable)
8-10	Excessive odour (objectionable)

The GC report of following 8 samples are as follows: **sample-1**

Page 1 of 1

Software Version	: 6.3.2.0646		Date	: 3/27/2012 3:18:36 PM
Sample Name	: HOT & TASTY (1)		Data Acquisition Time	: 3/27/2012 2:58:20 PM
Instrument Name	: Clarus 500 GC		Channel	: A
Rack/Vial	: 0/0		Operator	: TARUN TYAGI
Sample Amount	: 1.000000		Dilution Factor	: 1.000000
Cycle	: 1			

Result File : D:\Clarus 500 GC\Data\2012\MARCH\HOT & TASTY121-20120327-151627.rst
Sequence File : D:\Clarus 500 GC\Sequence\MARCH_2012.seq



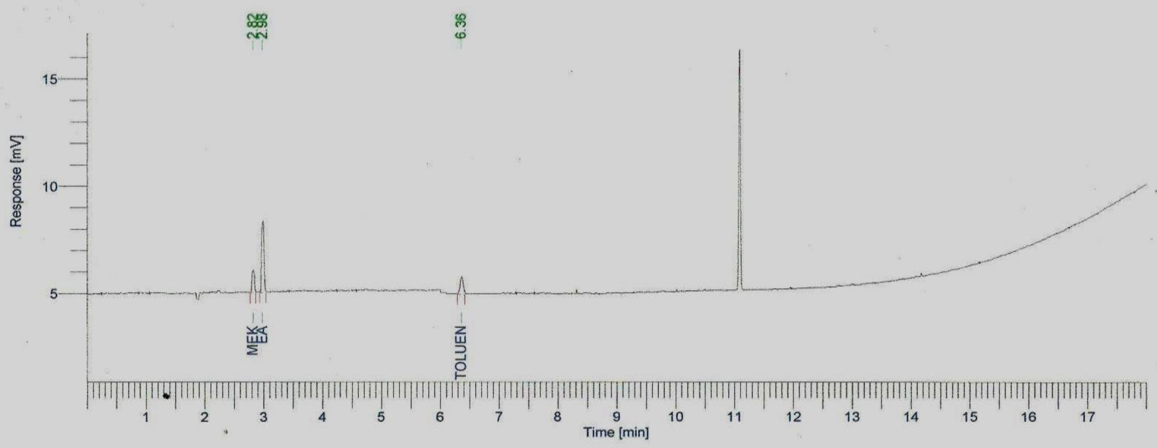
UFLEX LTD.(Chemical Division)

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	MEK	2.832	916.50	335.62	22.31	0.0607
2	EA	2.997	3190.70	1074.58	77.69	0.1222
			4107.20	1410.19	100.00	0.1829

Sample-2

Software Version	: 6.3.2.0646	Date	: 4/4/2012 4:08:42 PM
Sample Name	: ARMATO TWIGGLES (2)	Data Acquisition Time	: 4/4/2012 3:49:55 PM
Instrument Name	: Clarus 500 GC	Channel	: A
Rack/Vial	: 0/0	Operator	: TARUN TYAGI
Sample Amount	: 1.000000	Dilution Factor	: 1.000000
Cycle	: 3		

Result File : D:\Clarus 500 GC\Data\2012\APRIL\ARMATO TWIGGLES006-20120404-160808.rst
Sequence File : D:\Clarus 500 GC\Sequence\APRIL_2012.seq



UFLEX LTD.(Chemical Division)

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	MEK	2.823	2888.84	1032.35	19.09	0.1914
2	EA	2.985	9530.98	3305.38	62.97	0.3650
3	TOLUENE	6.364	2716.01	781.99	17.94	0.2698
			15135.83	5119.72	100.00	0.8262

Sample-3

Software Version	: 6.3.2.0646	Date	: 3/27/2012 3:47:18 PM
Sample Name	: SUNDROP (3)	Data Acquisition Time	: 3/27/2012 3:28:19 PM
Instrument Name	: Clarus 500 GC	Channel	: A
Rack/Vial	: 0/0	Operator	: TARUN TYAGI
Sample Amount	: 1.000000	Dilution Factor	: 1.000000
Cycle	: 2		

Result File : D:\Clarus 500 GC\Data\2012\MARCH\SUNDROP122-20120327-154627.rst
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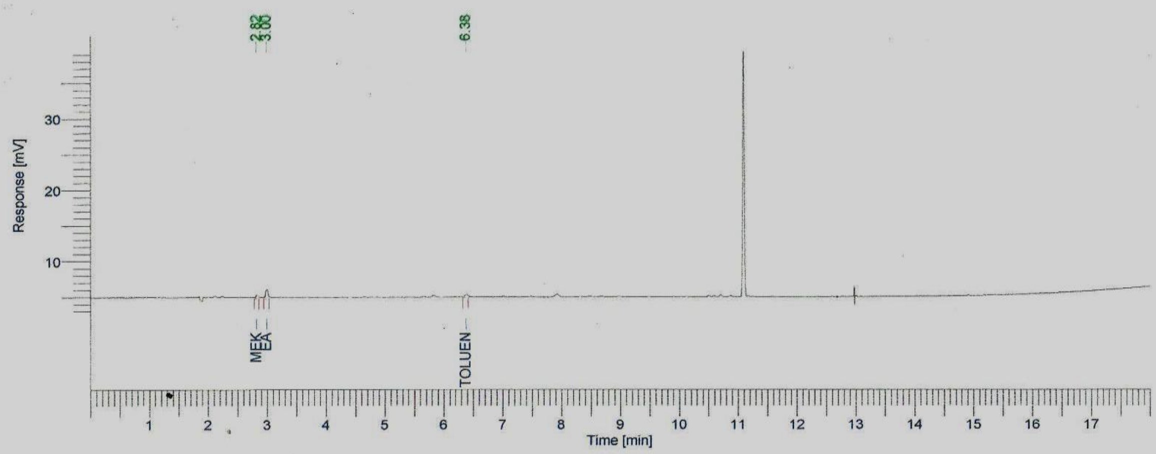

UFLEX LTD.(Chemical Division)

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	MEK	2.824	982.33	354.48	19.58	0.0651
2	EA	2.998	3043.23	1048.30	60.65	0.1166
3	TOLUENE	6.385	991.89	311.27	19.77	0.0985
			5017.45	1714.05	100.00	0.2802

Sample-4

Page 1 of 1

Software Version : 6.3.2.0646		Date	: 3/29/2012 3:47:32 PM
Sample Name : VICCO VAJRADANTI (4)		Data Acquisition Time	: 3/29/2012 3:27:55 PM
Instrument Name : Clarus 500 GC		Channel	: A
Rack/Vial : 0/0		Operator	: TARUN TYAGI
Sample Amount : 1.000000		Dilution Factor	: 1.000000
Cycle : 2			

Result File : D:\Clarus 500 GC\Data\2012\MARCH\VICCO VAJRADANTI135-20120329-154606.rst
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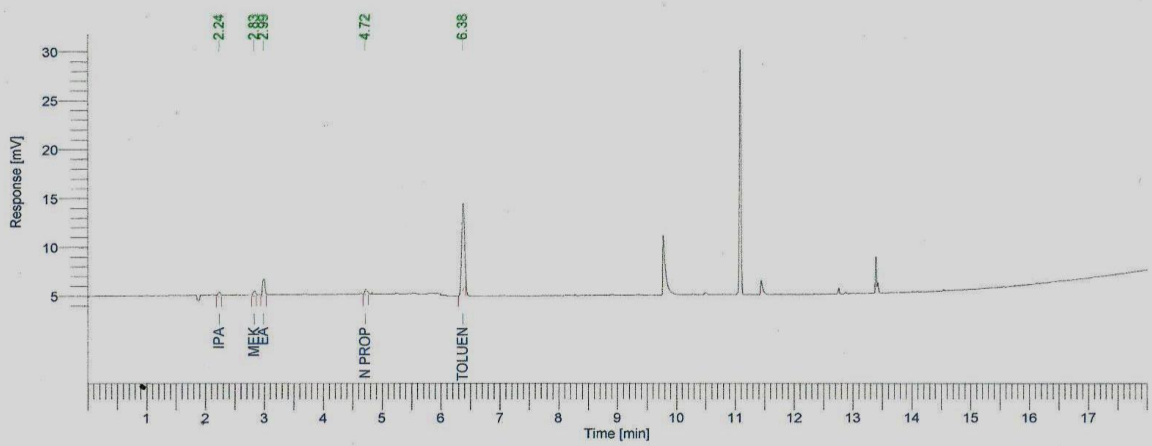


UFLEX LTD.(Chemical Division)

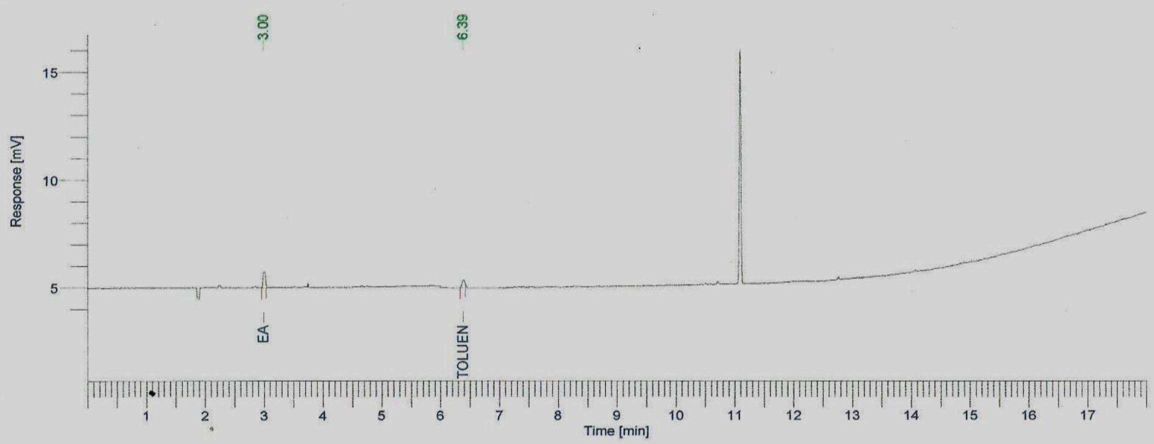
Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	IPA	2.241	915.12	312.53	2.43	0.2903
2	MEK	2.834	1109.13	410.17	2.94	0.0735
3	EA	2.995	4621.09	1613.44	12.26	0.1770
4	N PROPYL ACETATE	4.723	1397.24	488.03	3.71	0.0597
5	TOLUENE	6.377	29657.34	8821.83	78.67	2.9460
			37699.92	11645.99	100.00	3.5464

Sample-5

Software Version : 6.3.2.0646
Sample Name : WIPRO BABY SOFT (5)
Instrument Name : Clarus 500 GC
Rack/Vial : 0/0
Sample Amount : 1.000000
Cycle : 1

Date : 3/29/2012 3:46:40 PM
Data Acquisition Time : 3/29/2012 2:57:55 PM
Channel : A
Operator : TARUN TYAGI
Dilution Factor : 1.000000

Result File : D:\Clarus 500 GC\Data\2012\MARCH\WIPRO BABY SOFT134-20120329-151605.rst
Sequence File : D:\Clarus 500 GC\Sequence\MARCH_2012.seq



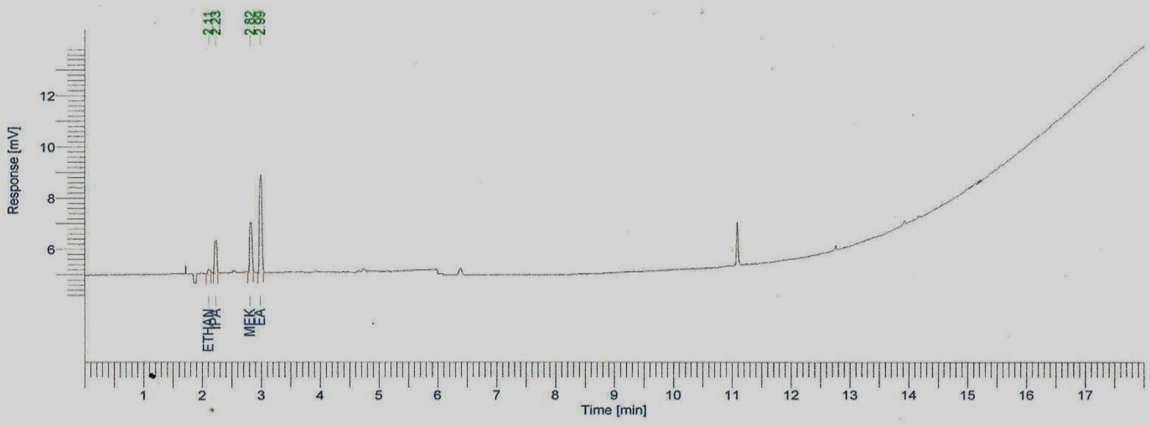
UFLEX LTD.(Chemical Division)

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	EA	2.996	2077.78	726.92	68.69	0.0796
2	TOLUENE	6.390	946.87	316.69	31.31	0.0941
			3024.65	1043.61	100.00	0.1736

Sample-6

Software Version	: 6.3.2.0646	Date	: 4/4/2012 3:51:25 PM
Sample Name	: HOT & TASTY PRINTED (6)	Data Acquisition Time	: 4/4/2012 2:49:56 PM
Instrument Name	: Clarus 500 GC	Channel	: A
Rack/Vial	: 0/0	Operator	: TARUN TYAGI
Sample Amount	: 1.000000	Dilution Factor	: 1.000000
Cycle	: 1		

Result File : D:\Clarus 500 GC\Data\2012\APRIL\HOT & TASTY PRINTED004-20120404-150807.rst
Sequence File : D:\Clarus 500 GC\Sequence\APRIL_2012.seq



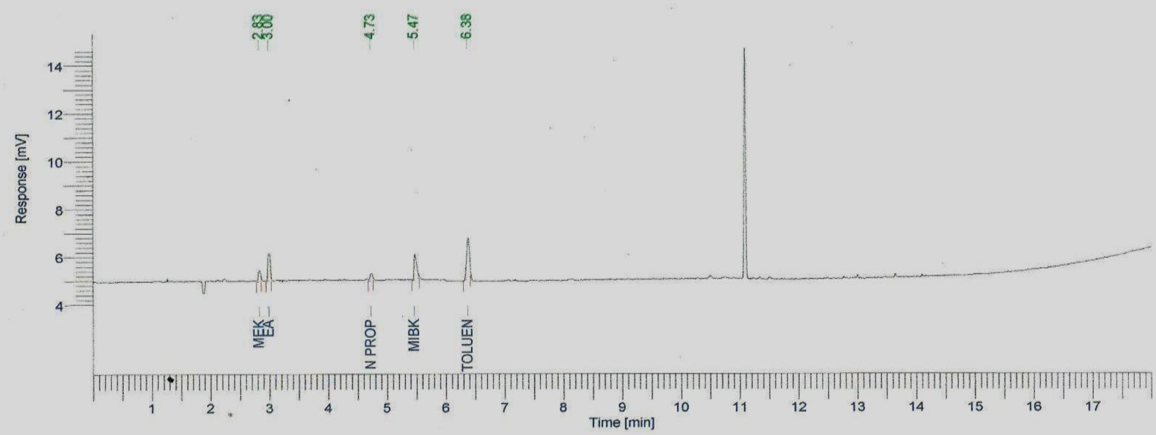
UFLEX LTD.(Chemical Division)

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	ETHANOL	2.111	448.35	150.23	2.16	0.1795
2	IPA	2.233	3658.18	1258.66	17.65	1.1604
3	MEK	2.817	5496.39	1940.72	26.52	0.3641
4	EA	2.988	11120.45	3803.92	53.66	0.4259
			20723.37	7153.53	100.00	2.1299

Sample-7

Software Version	: 6.3.2.0646	Date	: 3/27/2012 4:20:55 PM
Sample Name	: ARMATO TWIGGLES (7)	Data Acquisition Time	: 3/27/2012 3:58:18 PM
Instrument Name	: Clarus 500 GC	Channel	: A
Rack/Vial	: 0/0	Operator	: TARUN TYAGI
Sample Amount	: 1.000000	Dilution Factor	: 1.000000
Cycle	: 3		

Result File : D:\Clarus 500 GC\Data\2012\MARCH\ARMATO TWIGGLES123-20120327-161627.rst
Sequence File : D:\Clarus 500 GC\Sequence\MARCH_2012.seq



UFLEX LTD.(Chemical Division)

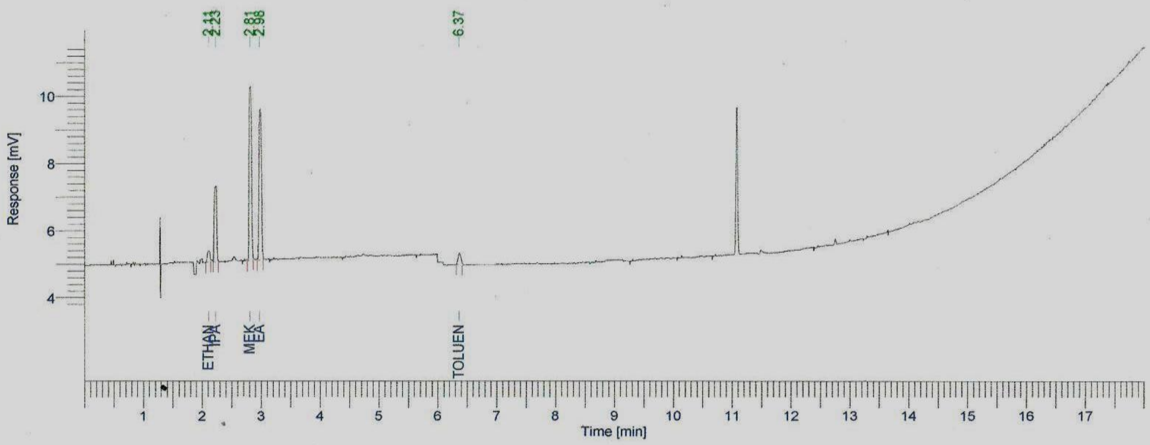
Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	MEK	2.831	1149.73	420.34	8.18	0.0762
2	EA	2.997	3280.08	1125.94	23.33	0.1256
3	N PROPYL ACETATE	4.731	749.72	265.99	5.33	0.0320
4	MIBK	5.471	3243.56	1038.52	23.07	0.1067
5	TOLUENE	6.379	5639.07	1657.05	40.10	0.5602
			14062.16	4507.84	100.00	0.9006

Sample-8

Software Version : 6.3.2.0646
Sample Name : SUNDROP PRINTED (8)
Instrument Name : Clarus 500 GC
Rack/Vial : 0/0
Sample Amount : 1.000000
Cycle : 2

Date : 4/4/2012 3:51:52 PM
Data Acquisition Time : 4/4/2012 3:19:56 PM
Channel : A
Operator : TARUN TYAGI
Dilution Factor : 1.000000

Result File : D:\Clarus 500 GC\Data\2012\APRIL\SUNDROP PRINTED005-20120404-153808.rst
Sequence File : D:\Clarus 500 GC\Sequence\APRIL_2012.seq



UFLEX LTD.(Chemical Division)

Peak #	Component Name	Time [min]	Area [uV*sec]	Height [uV]	Area [%]	AMOUNT (MG/SQM)
1	ETHANOL	2.112	900.17	308.77	2.47	0.3603
2	IPA	2.230	6530.48	2238.61	17.93	2.0714
3	MEK	2.814	14810.11	5148.87	40.67	0.9812
4	EA	2.980	13223.32	4481.66	36.31	0.5065
5	TOLUENE	6.369	951.05	304.34	2.61	0.0945
			36415.13	12482.24	100.00	4.0139

The Jar odour Test report of following 8 samples are as follows: **sample-1**

FLEX Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

F07(QAS/P/01)

Jar Odour Test Report

PRODUCT NAME : Hot & Tasty (only Printed), Sample. No - 1

JOB CODE : EN 3645 PRI Date : 15/3/2012

PARTICIPANT : R.V. Singh, B.P. Singh, Yogesh, Niranjan Kumar, Ankur Srivastava

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40°C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
R.V. Singh	1.		✓							
	2.									
	3.									
B.P. Singh	1.	✓								
	2.									
	3.									
Yogesh	1.	✓								
	2.									
	3.									
Niranjan Kumar	1.		✓							
	2.									
	3.									
Ankur Srivastava	1.	✓								
	2.									
	3.									

Rating Level		Description
1.	:	Essentially no odour (Blank jar smell)
2-3	:	Slight odour (Not objectionable.)
4	:	Noticeable odour (Borderline acceptable)
5-7	:	Appreciable odour (Objectionable)
8-10	:	Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED ✓ (ACCEPTED)

Sample-2

F07(QAS/P/01)

FLEX Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

Jar Odour Test Report

PRODUCT NAME : Armaro Twiggles (only printed), Sample No - 2

JOB CODE : EN 3591 Date : 15/3/12

PARTICIPANT : Niranjan Kumar, R.V. Singh, Yogesh, B.P. Singh, Ankur Srivastava

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40 °C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
Niranjan Kumar	1.		✓							[signature]
	2.									
	3.									
R.V. Singh	1.		✓							[signature]
	2.									
	3.									
Yogesh	1.	✓								[signature]
	2.									
	3.									
B.P. Singh	1.		✓							[signature]
	2.									
	3.									
Ankur Srivastava	1.		✓							[signature]
	2.									
	3.									

Rating Level	Description
1.	: Essentially no odour (Blank jar smell)
2-3	: Slight odour (Not objectionable.)
4	: Noticeable odour (Borderline acceptable)
5-7	: Appreciable odour (Objectionable)
8-10	: Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED ✓/REJECTED

Sd.

Sample-3

FLEX
Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

F07(QAS/P/01)

Jar Odour Test Report

PRODUCT NAME : Sundrop (Only printed), Sample No-3

JOB CODE : DN 25B PRI Date : 16/3/12

PARTICIPANT : Yogesh, Ankur Srivastava, R.V. Singh, B.P. Singh, Niranjan Kumar

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40 °C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
Yogesh	1.	✓								
	2.									
	3.									
Ankur Srivastava	1.	✓								
	2.									
	3.									
R.V. Singh	1.	✓								
	2.									
	3.									
B. P. Singh	1.		✓							
	2.									
	3.									
Niranjan Kumar	1.	✓								
	2.									
	3.									

Rating Level	Description
1.	: Essentially no odour (Blank jar smell)
2-3	: Slight odour (Not objectionable.)
4	: Noticeable odour (Borderline acceptable)
5-7	: Appreciable odour (Objectionable)
8-10	: Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED

Sd.

Sample-4

FLEX Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

F07(QAS/P/01)

Jar Odour Test Report

PRODUCT NAME : Vico vajradanti (only Printed), Sample No - 4

JOB CODE : DM 38SRI **Date :** 16/3/12

PARTICIPANT : Yogesh, R.V. Singh, Ankur Srivastava, B.P. Singh, Niranjan Kumar

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40°C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
Yogesh.	1.		✓							[signature]
	2.									
	3.			✓						
R.V. Singh	1.			✓						[signature]
	2.									
	3.									
Ankur Srivastava	1.			✓						[signature]
	2.									
	3.									
B. P. Singh	1.		✓							[signature]
	2.									
	3.									
Niranjan Kumar	1.			✓						[signature]
	2.									
	3.									

Rating Level	Description
1.	Essentially no odour (Blank jar smell)
2-3	Slight odour (Not objectionable.)
4	Noticeable odour (Borderline acceptable)
5-7	Appreciable odour (Objectionable)
8-10	Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED

Sd

Sample-5

F07(QAS/P/01)

FLEX
Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

Jar Odour Test Report

PRODUCT NAME : Klipro Baby Soft (Only printed) - Sample No-5

JOB CODE : BM 67 PR1 Date : 19/3/12

PARTICIPANT : Yogesh, Ankur Srivastava, R.V. Singh, B.P. Singh, Niranjan Kumar

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40 °C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
Yogesh	1.		✓							
	2.									
	3.									
Ankur Srivastava	1.		✓							
	2.									
	3.									
R.V. Singh	1.		✓							
	2.									
	3.									
B.P. Singh	1.	✓								
	2.									
	3.									
Niranjan Kumar	1.	✓								
	2.									
	3.									

Rating Level	Description
1.	: Essentially no odour (Blank jar smell)
2-3	: Slight odour (Not objectionable.)
4	: Noticeable odour (Borderline acceptable)
5-7	: Appreciable odour (Objectionable)
8-10	: Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED

Sd.

Sample-6

FLEX
Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

F07(QAS/P/01)

Jar Odour Test Report

PRODUCT NAME : Hot & Tasty (Print + Laminate); Sample No-6

JOB CODE : EN 3645 PR1 **Date :** 19/3/12

PARTICIPANT : Yogesh, R.V. Singh, Ankur Srivastava, B.P. Singh, Niranjan Kumar

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION : 40°C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
Yogesh	1.			✓						[illegible]
	2.									
	3.									
R.V. Singh	1.		✓							[illegible]
	2.									
	3.									
Ankur Srivastava	1.			✓						[illegible]
	2.									
	3.									
B.P. Singh	1.			✓						[illegible]
	2.									
	3.									
Niranjan Kumar	1.	✓								[illegible]
	2.									
	3.									

Rating Level	Description
1.	: Essentially no odour (Blank jar smell)
2-3	: Slight odour (Not objectionable.)
4	: Noticeable odour (Borderline acceptable)
5-7	: Appreciable odour (Objectionable)
8-10	: Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED

Sd

Sample-7

FLEX
Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

F07(QAS/P/01)

Jar Odour Test Report

PRODUCT NAME : Aromato Twiggles (Print + Laminate) - Sample No-7

JOB CODE : EN 3591 Date : 22/3/12

PARTICIPANT : R.V. Singh, Yogesh, Ankur Srivastava, B.P. Singh, Niranjan Kumar

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40°C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
				Rating Scale.						
R.V. Singh	1.		✓							[signature]
	2.									
	3.									
Yogesh	1.		✓							[signature]
	2.									
	3.									
Ankur Srivastava	1.			✓						[signature]
	2.									
	3.									
B.P. Singh	1.		✓							[signature]
	2.									
	3.			✓						
Niranjan Kumar	1.									[signature]
	2.									
	3.									

Rating Level		Description
1.	:	Essentially no odour (Blank jar smell)
2-3	:	Slight odour (Not objectionable.)
4	:	Noticeable odour (Borderline acceptable)
5-7	:	Appreciable odour (Objectionable)
8-10	:	Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED

Sd.

Sample-8

FLEX
Code No. 760084

FLEX INDUSTRIES LIMITED
PACKAGING DIVISION, NOIDA

F07(QAS/P/01)

Jar Odour Test Report

PRODUCT NAME : Eclipse Baby Soft (Print + Laminate), Sample No-8

JOB CODE : DB 67 PR1 Date : 24/3/12

PARTICIPANT : Ankur Srivastava, R.V. Singh, Yogesh, B.P. Singh, Niranjan Kumar

SAMPLE SIZE : 144 Sq. Inches±10%

TEST CONDITION: 40 °C for 1 Hour

EQUIPMENT : Glass Jar 500 ML.

REPORTING : Compare the intensity of the Solvent Odour of each sample to that of the reference and Quantify the intensity as per the test procedure.

Rating Scale.

PANEL MEMBER	SAMPLE NO.	1	2	3	4	5	6-7	8-10	REMARKS	SIGNATURE
Ankur Srivastava	1.			✓						[signature]
	2.									
	3.									
R.V. Singh	1.			✓						[signature]
	2.									
	3.									
Yogesh	1.		✓							[signature]
	2.									
	3.									
B.P. Singh	1.				✓					[signature]
	2.									
	3.									
Niranjan Kumar	1.			✓						[signature]
	2.									
	3.									

Rating Level		Description
1.	:	Essentially no odour (Blank jar smell)
2-3	:	Slight odour (Not objectionable.)
4	:	Noticeable odour (Borderline acceptable)
5-7	:	Appreciable odour (Objectionable)
8-10	:	Excessive odour (Objectionable)

DECISION: MATERIAL IS ACCEPTED/REJECTED

We took 8 samples out of which first 5 were only printed (monolayer) and the sample no. 6, 7, 8 were double layer (laminated) and this lamination was done on the first 3 samples which were monolayer.

Gas Chromatography was done on these packaging film samples to know the solvent retention of various solvents like MEK, EA, Toluene, N Propyl Acetate, Isopropyl Alcohol(IPA), Ethanol, MIBK . GC gives the accurate value of these solvents retained by the samples in MG/SQM.

On the basis of GC reports we can say that first five samples which were only printed and monolayer solvent retention seems to be very low, for example value of ethyl acetate for the first five sample was found to be 0.122, 0.3650, 0.1166, 0.1770, .0796. But as we laminate the first 3 samples (sample no-6, 7, 8) some more solvents appear in the graph due to adhesive and laminate structure, and peaks appear higher.

So on the basis of GC reports we can say that as the laminate layer increased in the packaging film there will be more solvent retention which results in higher peaks.

After GC we also performed Jar Odour Test to know the intensity of odour in various samples. In this test specific dimensions of the samples (6dm2) is placed in 1 litre jar and after covering the lid with aluminium foil placed in oven at 40oC for 1 hour. After that panel members sniff the jar and gives the rating to the samples according to the intensity of odour. If the rating is less than or equal to four than the sample is accepted otherwise it is rejected.

CHAPTER 5 CONCLUSION

When we compared the data obtained by the GC reports i.e. solvents retained by the samples with the permissible value of Uflex Private Limited and Food & Drug Administration we found that obtained value is much below than acceptable value as shown in following table-

Solvent	Permissible value(mg/sqm)	Sample 1	Sample 2	sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
Ethanol	25	-	-	-	-	-	0.1795	-	0.3603
IPA	25	-	-	-	0.2903	-	1.1604	-	2.0714
MEK	15	0.0607	0.1914	0.0651	0.0735	-	0.3641	0.0762	0.9812
EA	25	0.1222	0.3650	0.1166	0.1770	0.0796	0.4259	0.1256	0.5065
Toluene	15	-	0.2698	0.0985	2.9460	0.0941	-	0.5602	0.0945
MIBK	15	-	-	-	-	-	-	0.1067	-
N propyl acetate	25	-	-	-	0.0597	-	-	0.0320	-

Table-13

On comparison we found that solvent retention for monolayer samples is less than double layer samples. On the basis of jar odour test, we have found that odour for monolayer is comparatively less than double layer because in the later samples more solvents present due to the use of adhesive and extra layer and hence we can say that as the laminate layer increases odour increase and above listed solvents in the table are the main causes of odour.

Odour can occur in the samples because of improper curing. Many industries for getting more output increases the speed of machine so that solvent evaporation does not occur properly and this solvent can impart odour to the laminates. One of the other main reason of the odour is the reaction between adhesive and ink used.

For example, permissible speed for the solvent base machine is 100-200m/min and for the solvent less machine is 200-350m/min and the temperature for PET, BOPP and Polyamide are 90-100^{o}C, 65-80^{o}C and 65-85^{o}C respectively. But when we increase the speed of machine, proper curing does not occur and it can leave the odour.

Future Work:

As we have seen that odour in the packaging materials can occur due to improper curing(solvent retention), reaction between the ink and adhesive used, scalping(chemical reaction between package and its content)etc. So in future our work will be to select the proper ratio of adhesive, resin, and ink for the particular packaging material, so that proper curing may occur.

CHAPTER 6 REFERENCES

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