FABRICATION AND ASSESSMENT OF ACACIA GUM-BASED HYDROGEL FOR DELIVERY OF CIPROFLOXACIN

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CHEMISTRY

by

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CANDIDATE'S DECLARATION

We Anshul (2k22/MSCCHE/02) and Garima Tomar (2k22/MSCCHE/10) hereby certify that the work which is being presented in the dissertation enlightened **"Fabrication and Assessment of Acacia Gum-Based Hydrogel for Delivery of Ciprofloxacin"** in partial fulfillment of the requirements for the award of the Degree of Master in Science, submitted in the Department of Applied Chemistry, Delhi Technological University is an authentic record of my own work carried out during the period from Aug 2023 to Mar 2024 under the supervision of Prof. Sudhir G. Warkar.

The matter presented in this dissertation has not been submitted by us for the award of any other degree of this or any other institute.

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CERTIFICATE BY THE SUPERVISOR(s)

Certified that Anshul (2k22/MSCCHE/02) and Garima Tomar (2k22/MSCCHE/10) has carried out their research work presented in this dissertation entitled **"Fabrication and Assessment of Acacia Gum-Based Hydrogel for Delivery of Ciprofloxacin"** for the award of Master of Science from the Department of Applied Chemistry, Delhi Technological University, Delhi, under my supervision. The dissertation embodies results of original work, and studies are carried out by the students herself and the contents of the dissertation do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

Place - New Delhi

Date -

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ABSTRACT

In the current research, various hydrogel formulation comprised of acacia gum (AG), polyacrylamide (PAM), and carboxymethyl tamarind kernel gum (CMTKG) were fabricated and ciprofloxacin loading were carried out. The evaluation of different crosslinker and initiator amount on the swelling ratio of the synthesized hydrogel was assessed. Powder X-ray Diffraction (PXRD), Scanning Electron Microscopy (SEM), and Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR) techniques were used to characterize the hydrogel. The hydrogel swelling and in vitro drug release were evaluated using buffer of pH 1.2 and 7.4. The results showed that, in comparison to acidic pH, an alkaline pH produced better results for the swelling and in vitro drug release. The ciprofloxacin-loaded AG/PAM/CMTKG hydrogel drug release kinetics revealed non-fickian mechanism at pH 7.4 and fickian diffusion at pH 1.2, respectively, according to the Korsmeyer–Peppas model. The pH-dependent behavior of ciprofloxacin-loaded AG/PAM/CMTKG hydrogel displayed its possible consequences for site-specific ciprofloxacin release.

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LIST OF ABBREVIATIONS AND SYMBOLS

AG-Acacia Gum

AM- Acrylamide

ATR-FTIR- Attenuated Total Reflection- Fourier Transform Infrared Spectroscopy

CMTG- Carboxymethyl Tamarind Gum

CMTKG- Carboxymethyl Tamarind Kernel Gum

CNS- Central Nervous System

$-COO^-$ - Carboxylate ion

$-CONH_2$ - Amide group

Cukα- Copper kα

DEE- Drug Entrapment Efficiency

g- Gram

HCL- Hydrogen chloride

IPN- Interpenetrating Polymeric Hydrogel

KPS- Potassium per sulphate

KCL- Potassium Chloride

MBA- N', N' -methylene-bis (acrylamide)

mg- Milligram

N_2 - Dinitrogen

NH_2- Amine group

OH- Hydroxyl group

PAM- Polyacrylamide

PEG- Polyethylene glycol

PVA- Polyvinyl alcohol

PVP- Polyvinyl pyrrolidone

PXRD- Powder X-ray diffraction

R^2- Regression coefficient

$-SO_3H$- Sulfonic group

SEM- Scanning Electron Microscopy

SR- Swelling Ratio

TMC- Trimethyl Chitosan

TKG- Tamarind Kernel Gum

UV-Vis- Ultraviolet- visible spectroscopy

W_d- Weight of dried hydrogel

W_s- Weight of swollen hydrogel

XG- Xanthan Gum

%- Percentage

λ_{max}- Maximum Wavelength

CHAPTER 1

INTRODUCTION AND LITERATURE SURVEY

Hydrogel is a three-dimensional network of hydrophilic polymers joined by chemical or physical cross-links & have ability to expand without losing its structural integrity. Hydrophilic groups like $-NH_2$, -OH, -COOH, $-CONH_2$, $-SO_3H$ etc are present in these hydrogel network [1]. Hydrogels are useful in biological and pharmaceutical applications due to of their excellent absorbency, hydrophilic nature, and softness[2]. Hydrogels are a good option for regulated drug administration because to their bio-adhesive properties, which also improve tissue permeability and drug residence time[1].

In recent years, hydrogels are becoming more and more popular as drug delivery vehicles due to their non-toxicity and biocompatibility , especially for oral drug delivery[3]. Furthermore, hydrogels that respond to certain environmental conditions by changing their volume are referred to as intelligent or smart hydrogels. They responds to chemical stimuli like pH, ionic strength or biological stimuli like enzymes, DNA and physical stimuli like light, pressure, temperature, and ultrasound [1]. However, pH-sensitive hydrogels have been researched widely among all other stimuli. The hydrogels, which are pH-sensitive, have weak acidic or basic groups that easily ionize at higher or lower pH values, with respect to their pKa values [3], [4].

Polyacrylamide is non-toxic, pH-responsive polymer which respond to different physical and chemical stimuli with notable volume variations [5], [6], [7]. PAM hydrogels are recognized for their biocompatible qualities, as they do not cause any harm to human fibroblasts. Additionally, these hydrogels show resistance to particular bodily enzymes and are neither carcinogenic nor allergic, reducing the possibility of mutagenesis effects. As a result, these hydrogels highlight their adaptability in a range of biological applications [6].

Recently, the combination of desired properties from both natural and synthetic polymers has led to a recent surge in interest in hybrid hydrogels. TKG and its derivatives have been employed as a effective biopolymer substitute for synthetic polymers due to its variable solubility, biodegradability, lack of toxicity, and susceptibility to microbial breakdown. It is obtained from the seeds of Tamarindus indica L. and made up of glucose, galactose, and xylose in a molar ratio of 3:2:1 [8]. Numerous TKG-based modified products have been investigated for use in a variety of industries, including the food, textile, explosives, plywood, and medical sectors [8].

One notable example is the derivative of tamarind kernel gum (TKG), carboxymethyl tamarind kernel gum (CMTKG). This chemical modification of TKG enhances features such as shell integrity, drug loading efficiency, swelling ratio, bio

adhesiveness, and hydrophilicity [9]. CMTKG structural and physicochemical properties help them to be used in tissue engineering and medication delivery systems[10].It has been widely employed in the fabrication of numerous therapeutics agents, including hydrogels, films, nanoparticles, composites, and pellets, in the field of drug delivery systems[11].

Acacia gum is a polysaccharide with a high branch structure that is extracted as a dried exudate from the branches and stems of Acacia Senegal [12], [13]. Its major structural components are α-L-arabinofuranosyl, ß-D-glucuronopyranosyl, 4-O-methyl-ß-D-glucuronopyranosyl, and α-L-rhamnopyranosyl units [12]. It is typically found in areas that stretch from the Indian Peninsula to West Africa [14], [15]. Acacia Gum is widely used in the pharmaceutical and food industries. It exhibits powerful antioxidant qualities due to the presence of hydrocolloids [13].

Ciprofloxacin, also known as 1-cyclopropyl-6-fluoro-4-oxo-7-(piperazin-1-yl)-quinoline-3-carboxylic acid, is a member of the fluoroquinolone family. Its structure consists of a piperazine ring at position 7 and a quinolone core with a fluorine atom at position 6 [16], [17], [18], [19]. Ciprofloxacin, like all fluoroquinolones, primarily acts by inhibiting DNA gyrase. Gyra A and Gyra B are the two subunits of DNA gyrase. Subunit A appears to be the main target of ciprofloxacin [20]. Ciprofloxacin exhibits superior tissue dispersion compared to numerous other drugs in its class due to its low binding to plasma proteins. When taken orally, it effectively penetrates the majority of bodily fluids and tissues, except for the central nervous system (CNS)[21]. The kidneys are primarily responsible for removing ciprofloxacin from the body through a combination of tubular secretion and glomerular filtration [20]. It's widely used to treat infections of the skin, gastrointestinal tract, and urinary tract [18].

This study focuses on fabrication of ciprofloxacin-loaded AG/PAM/CMTKG hydrogel using the different crosslinker and initiator concentration. The hydrogels were characterized using PXRD, ATR-FTIR, SEM analysis. In stimulated physiological solutions with pH values of 1.2 and 7.4, the analysis of drug release and swelling was conducted. To investigate the drug release mechanisms, a number of kinetic models were used, including Korsmeyer-Peppas, Zero-order, Hixson Crowell, First order, Higuchi.

Table 1.1: Literature on bio-polymer based hydrogel used in controlled drug delivery systems

Hydrogel	Cross linking agent	Application	References
TMC/Sodium carboxymethyl xanthan gum	MBA	Ciprofloxacin release	[22]
CMTG	Citric Acid	Moxifloxacin hydrochloride release	[23]
Gelatin/Poly methacrylic	MBA	Salbutamol release	[24]
CMTKG/PAM/PEG	MBA	Etophylline release	[25]
XG/PAM/PVP	MBA	Ibuprofen Release	[26]
Acacia gum-polyvinylpyrollidone/ carbopol	MBA	Moxifloxacin	[13]
Sodium Alginate/PVA	MBA	Diclofenac Sodium release	[27]
Chitosan/Gelatin	Tris(2-(2-formylphenoxy) ethyl) amine	metronidazole	[28]

CHAPTER 2

MATERIAL AND METHODS

2.1. Materials

CMTKG (Courtesy Hindustan Gum and Chemicals Ltd., Bhiwani, Haryana), ciprofloxacin (Unicure Pvt. Ltd.), potassium persulphate (KPS, Fischer Scientific, Bombay, India), *N*, *N*′-methylene bisacrylamide (MBA, Merck, Germany), acrylamide (AM, CDH, New Delhi) and acacia gum (AG, Thermo Fisher Scientific India Pvt. Ltd. Mumbai, India),were utilized as provided.

2.2. Synthesis of AG/PAM/CMTKG hydrogels and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel

Different formulations of AG/PAM/CMTKG hydrogels were produced, with varying amounts of KPS (B1-B5) and MBA (B6-B9) as displayed in Table 2.1. Specific amounts of AG, PAM, and CMTKG were dissolved in distilled water and stirred for an hour in order to produce the AG/PAM/CMTKG hydrogels. KPS and MBA were then added, and stirring was done continuously for a further hour. After that, the solution was placed in a test tube and heated to 60 °C in a water bath for one hour. The hydrogel was extracted from the test tube, divided into pellets, and dried for 48 hours at 60 °C[7].

A slightly modified version of the same procedure was used to generate a ciprofloxacin-loaded AG/PAM/CMTKG hydrogel. Ciprofloxacin was added when KPS and MBA were introduced, while the remaining steps followed to the similar protocols as depicted in Fig. 2.
[29].

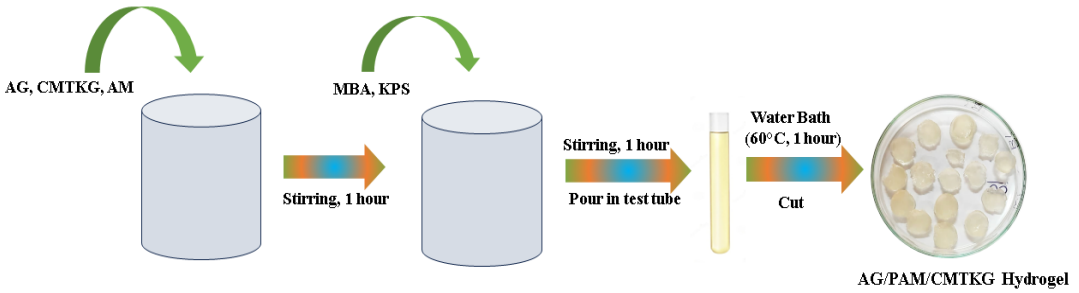


Fig. 2 Synthesis of AG/PAM/CMTKG hydrogels.

Table 2.1. Quantity of materials used in the AG/PAM/CMTKG hydrogels synthesis, with their swelling ratio.

Sample Code	KPS (mg)	MBA (mg)	CMTKG (g)	PAM (g)	AG (g)	Swelling Ratio (%)	
						pH 1.2	pH 7.4
B-1	36	12	0.25	0.5	0.2	837	968
B-2	36	17	0.25	0.5	0.2	746	935
B-3	36	22	0.25	0.5	0.2	662	863
B-4	36	27	0.25	0.5	0.2	685	737
B-5	36	32	0.25	0.5	0.2	615	723
B-6	18	12	0.25	0.5	0.2	702	857
B-7	24	12	0.25	0.5	0.2	756	907
B-8	30	12	0.25	0.5	0.2	801	968
B-9	42	12	0.25	0.5	0.2	709	815

CHAPTER 3

EXPERIMENTAL SECTIONS

3.1. Swelling Analysis

The gravimetric technique was employed to determine the swelling ratios of the hydrogels [30]. After being dried, hydrogel discs were submerged in phosphate buffer saline (pH 7.4) and HCl- KCl buffer (pH 1.2) [31]. The hydrogel was taken out of the buffer at a regular interval of 1 hr. The extra liquid from the hydrogel disc was blotted with filter paper, and the discs were weighed. [32]. Again, the discs were submerged in the same solution and the swelling was assessed using the given equation [28].

$$\text{Swelling ratio (\%)} = \frac{W_f - W_i}{W_i} * 100 \quad (1)$$

where the weights of the dry hydrogel sample and the swelled hydrogel sample are represented by W_f and W_i, respectively. [33].

3.2. Drug encapsulation efficiency

For ciprofloxacin-loaded AG/PAM/CMTKG hydrogel, the drug encapsulation efficiency was measured. The 0.1 g ciprofloxacin-loaded AG/PAM/CMTKG hydrogel disc were crushed and submerged in a 100 ml pH 7.4 buffer solution for 48 hr [34]. The absorbance was assessed using a UV-visible spectrophotometer and the amount of ciprofloxacin was determined using a calibration curve [35]. The stated formula was employed to determine the drug encapsulation efficiency (DEE %) [36],[34].

$$\text{DEE \%} = \frac{\text{Amount of drug loaded in hydrogel pellet}}{\text{Theoretical amount of drug in a hydrogel pellet}} \times 100 \quad (2)$$

3.3. In vitro Ciprofloxacin release

The ciprofloxacin loaded AG/PAM/CMTKG hydrogel was analyzed for an in vitro release study in an incubator shaker using buffer solutions with a pH of 1.2 and 7.4. At 37°C, a hydrogel was submerged in 100 ml of buffer solution then 3ml of the buffer solution were removed after an hour, and the same amount of fresh buffer was added .The study was conducted three times, and a UV-visible spectrophotometer was used to measure the absorbance of released ciprofloxacin at λmax 277 nm.The ciprofloxacin calibration curve was utilized to ascertain the amount of drug present in the hydrogel [37].

3.4. Kinetic modelling

The kinetic modelling was performed to examine the release of ciprofloxacin from a ciprofloxacin-loaded AG/PAM/CMTKG hydrogel using Korsmeyer-Peppas, Zero-order, Higuchi, Hixson-Crowell and First-order models. Following a comparison of each model's coefficient of determination (R^2) values, the model that best fits the data is the one whose R^2 value is closest to unity[38].

3.5. Characterization

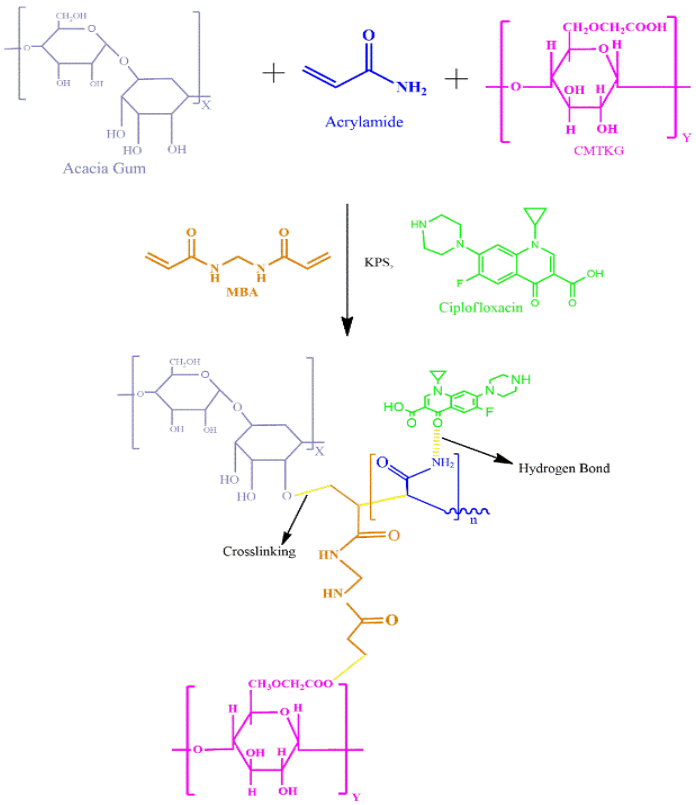
PXRD was examined using CuKα radiation at 2Θ range of 10-70° with a Bruker D8 diffractometer. The ATR-FTIR spectrophotometer (Model: PerkinElmer spectrum 2) was used to record ATR-FTIR spectra in the wavenumber range of 450-4000 cm^{-1}. The SEM images were obtained using SEM (Model: JEOL Japan Mode: JSM 6610LV).

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Mechanism of AG/PAM/CMTKG and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel

With varying the amounts of KPS and MBA, the hydrogels were produced by a free radical chain polymerization process as depicted in Table 2.1. When KPS break down at 60 °C, sulfate radicals were produced. These radicals react with AM by cleaving its vinyl bond, in order to produce the radicals. Subsequently, these AM radicals attacked other acrylamide molecules to start the propagation, which led to the synthesis of PAM. Furthermore, by cleaving the -OH bond, the sulfate radical also generates the radical on CMTKG and AG. By connecting these active radicals, the MBA further forms the covalent crosslinked bond, generating a three-dimensional (3-D) AG/PAM/CMTKG hydrogel network .The formation of a three-dimensional network of ciprofloxacin-loaded AG/PAM/CMTKG hydrogel is facilitated by the hydrogen bonding interaction between ciprofloxacin and PAM., as depicted in Scheme 4.1 [39].



Scheme 4.1. Mechanism of ciprofloxacin-loaded AG/PAM/CMTKG hydrogel.

4.2. Swelling Analysis

The effect of the initiator and cross-linker amount on the hydrogels swelling is displayed in Fig. 4.1 and its data is shown in Table 2.1

4.2.1 Impact of cross-linker

An apparent decrease in the swelling capacity with an increase in MBA amount was observed in Fig. 4.1 (a). This observed fall in swelling can be explained by the increased crosslink density resulting from the rise in concentration of the crosslinker which restricts its capacity to absorb and retain the absorbed fluid effectively. When the hydrogel concentration below than 12 mg, there is no evident crosslinking, suggesting that the hydrogel network does not formed [40].

4.2.2. Impact of initiator

The MBA concentration maintained at 12 mg, and swelling effects were examined for variations in KPS content. The decrease in swelling is observed below 36 mg of KPS content, it is explained by the availability of unreacted monomers due to a lesser number of initiator free radicals. Additionally, swelling decreases when initiator concentrations higher than 36 mg due to the formation of oligomers from the subsequent collision of monomer radicals Fig.4.1(b). As a result, the oligomeric components became soluble throughout the swelling experiment, which causes decrease in overall swelling ratio of hydrogel [29].

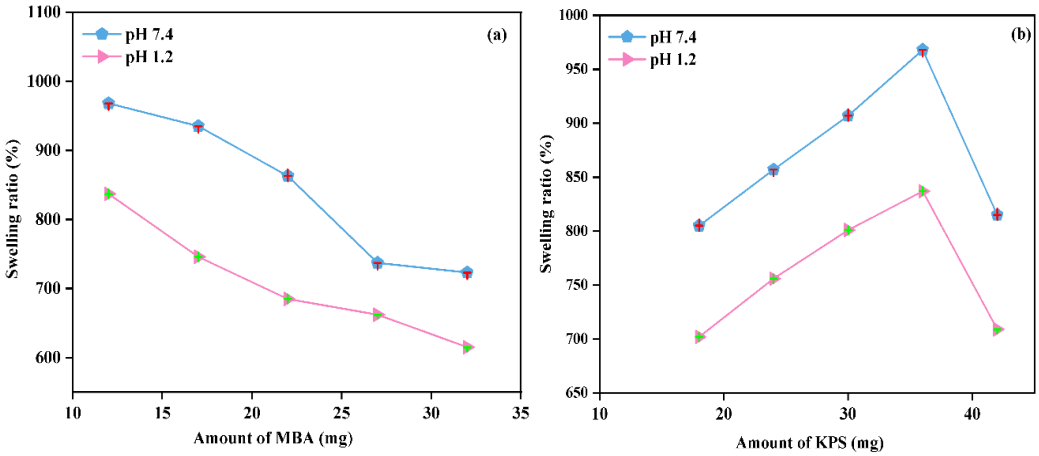


Fig.4.1. Impact of **(a)** MBA, and **(b)** KPS on the swelling ratio.

From the swelling results, it was observed that formulation B-1 exhibits the maximum amount of swelling, as illustrated in Fig. 4.2. Additionally, at pH 7.4, all hydrogels exhibit better swelling, which is explained by the production of COO^- ions by the deprotonation of carboxylic acid of CMTKG. There is an increase in swelling caused by the relaxation of the polymer framework induced by the repulsion between

COO^- ions, which creates more space for fluid to enter effectively. On the other hand, at pH 1.2, hydrogen bonding between the polymeric chains cause the polymer network to compress , which reduces swelling [39].

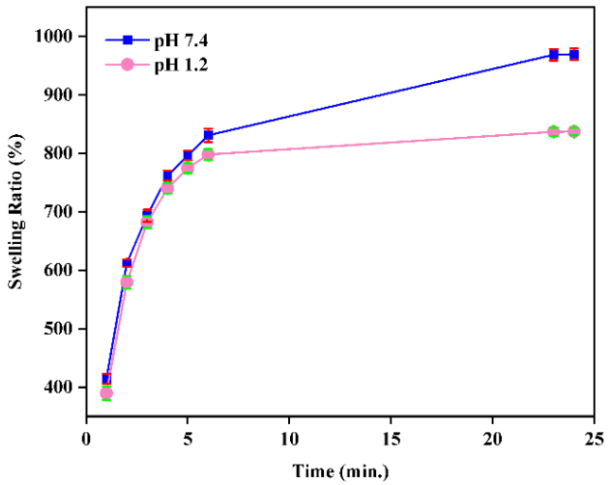


Fig.4.2. Swelling plot of AG/PAM/CMTKG hydrogel (B-1) in pH 1.2 and 7.4.

4.3. Drug encapsulation efficiency

Drug encapsulation efficiency of the ciprofloxacin-loaded AG/PAM/CMTKG hydrogel were evaluated. The drug encapsulation efficiency (%) is calculated to be 58.17 % for ciprofloxacin-loaded AG/PAM/CMTKG hydrogel.

4.4. In vitro ciprofloxacin release

The *in vitro* release was done for the ciprofloxacin-loaded AG/PAM/CMTKG hydrogel, as seen in Fig. 4.3 The maximum amount of ciprofloxacin release from this hydrogel was measured at pH 1.2 (16.6%) and pH 7.4 (56.3%). At pH 7.4, there is a significantly higher drug release than at pH 1.2, which suggests that the carboxylic acid group of CMTKG has deprotonated. These deprotonated carboxylate ions cause an electrostatic repulsion that expands the hydrogel network, causes swelling, and enhances the diffusion of ciprofloxacin from the hydrogel. On the other hand, because of the hydrogen bonds between the polymers, the polymeric network shrinks at pH 1.2. Therefore, the swelling ratio decreases, causing a lower ciprofloxacin release. Moreover, it was observed that without a burst effect, the ciprofloxacin was released from the hydrogels gradually. Its gradual release minimizes the need for frequent reductions in dosage by ensuring an ideal and maintained medication level over prolonged periods of time. These results imply that the ciprofloxacin-loaded AG/PAM/CMTKG hydrogel can be used to achieve the pH-dependent release of ciprofloxacin [40].

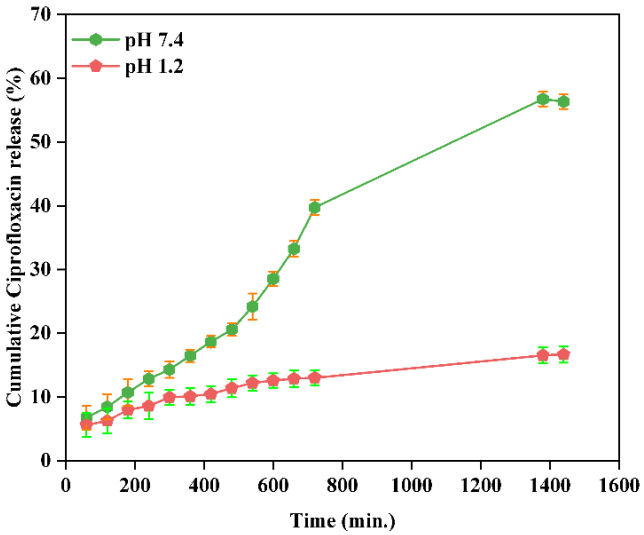


Fig.4.3. Drug release from ciprofloxacin-loaded AG/PAM/CMTKG hydrogel in pH 7.4 and 1.2.

4.5. Kinetic modelling

To examine the ciprofloxacin release kinetics of the ciprofloxacin loaded AG/PAM/CMTKG hydrogel, various types of models were utilized. The Korsmeyer–Peppas model has the greatest R^2 value out of these models., as observed in Table 4.1. The R^2 and n-values for the Korsmeyer-Peppas model were found to be 0.9885 and 0.622, respectively, at pH 7.4. The R^2 value and n value at pH 1.2 were found to be 0.9947 and 0.3149, respectively., (Fig. 4.4). These n values indicate that the Fickian diffusion mechanism is followed for the release of ciprofloxacin at pH 1.2. On the other hand, non-Fickian diffusion is shown at pH 7.4, indicating that the rates of diffusion and polymer chain relaxation were similar [41].

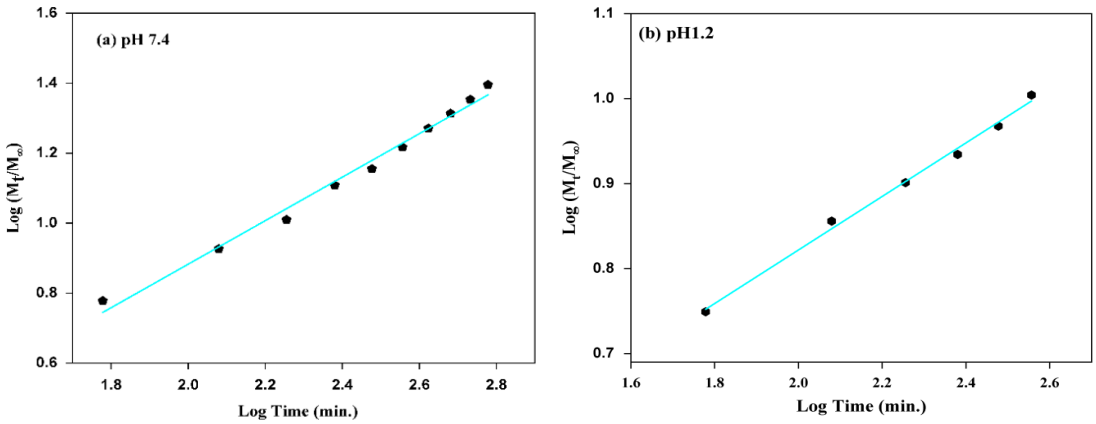


Fig.4.4. Kinetics of ciprofloxacin conforming to the Korsmeyer–Peppas model in (a) pH 7.4, and (b) pH 1.2.

Table 4.1. Kinetic modelling data of ciprofloxacin-loaded AG/PAM/CMTKG hydrogel.

Model	Equation	Swelling Ratio (%)				Ref.
		pH 7.4		pH 1.2		
		n	R^2	n	R^2	
Zero Order	$M_t = M_\infty + k_0 t$	-	0.8859	-	0.9641	[42]
Korsmeyer–Peppas	$M_t/M_\infty = kt^n$ k = kinetic constant n = diffusion exponent	0.622	0.9885	0.3149	0.9947	[24]
First Order	$\text{Log } M_t = \text{Log } M_\infty + \frac{kt}{2.303}$ k = rate constant	-	0.7659	-	0.8586	[43], [44]
Higuchi	$M_t/M_\infty = k_H t^{1/2}$ k_H = kinetic constant	-	0.9537	-	0.9697	[26]
Hixson-Crowell	$(M_t)^{1/3} - (M_\infty)^{1/3} = k_{HC}.t$ k_{HC} = Hixson Crowell constant	-	0.8248	-	0.8575	[24]

4.6. Characterisation

4.6.1. PXRD

PXRD was carried out for ciprofloxacin, AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel as depicted in Fig. 4.5. The sharp peak recorded at 2Θ values of 11.5, 24.72,19.39, 26.4 in ciprofloxacin, determining its crystalline nature [45]. The ciprofloxacin-loaded AG/PAM/CMTKG hydrogel and AG/PAM/CMTKG hydrogel possess a broad amorphous band. Additionally, the ciprofloxacin-loaded AG/PAM/CMTKG-loaded hydrogel have no extra sharp peaks of ciprofloxacin, demonstrating the complete dispersion of ciprofloxacin across the amorphous crosslinked network [27].

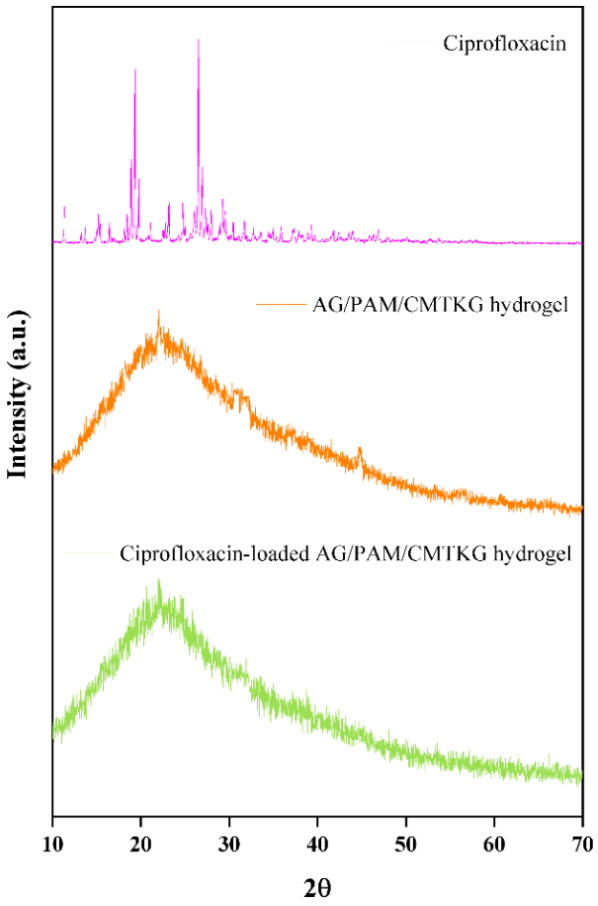


Fig.4.5. PXRD of ciprofloxacin, AG/PAM/CMTKG hydrogel (B-1), and ciprofloxacin-loaded AG/ PAM/CMTKG hydrogel.

4.6.2 ATR-FTIR

In ATR-FTIR spectra of the synthesized MBA, AG/PAM/CMTKG hydrogel (B-1) and ciprofloxacin-loaded AG/PAM/CMTKG are presented in Fig. 4.6. The AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel, showing the peaks at 3438 cm^{-1} and 3437 cm^{-1} of the -OH and -NH overlap stretching. The COO^- symmetric peak occurred at 1316 cm^{-1} and 1319 cm^{-1}, and the asymmetric stretch observed at 1657 cm^{-1} and 1659 cm^{-1} for AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel. The C-H peak of AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel appears at 2925 cm^{-1} and 2923 cm^{-1} respectively [29]. Furthermore , the appearance of C–O–C peak was seen at 1101 cm^{-1} and 1097 cm^{-1} for AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel [23]. In the MBA, the peaks noticed at 1304 cm^{-1}, corresponds to the C-N stretch, shift to 1316 cm^{-1} and 1319 cm^{-1} in the AG/PAM/CMTKG and ciprofloxacin-loaded AG/PAM/CMTKG, signifying reduced conjugation due to cross-linking. As a result, the hydrogel comprising AG/PAM/CMTKG and AG/PAM/CMTKG loaded with ciprofloxacin has been effectively synthesized. A comparison of the ciprofloxacin-

loaded AG/PAM/CMTKG hydrogel with the unloaded hydrogel did not reveal any extra peak, revealed the physical interaction of the drug and polymer chain [46].

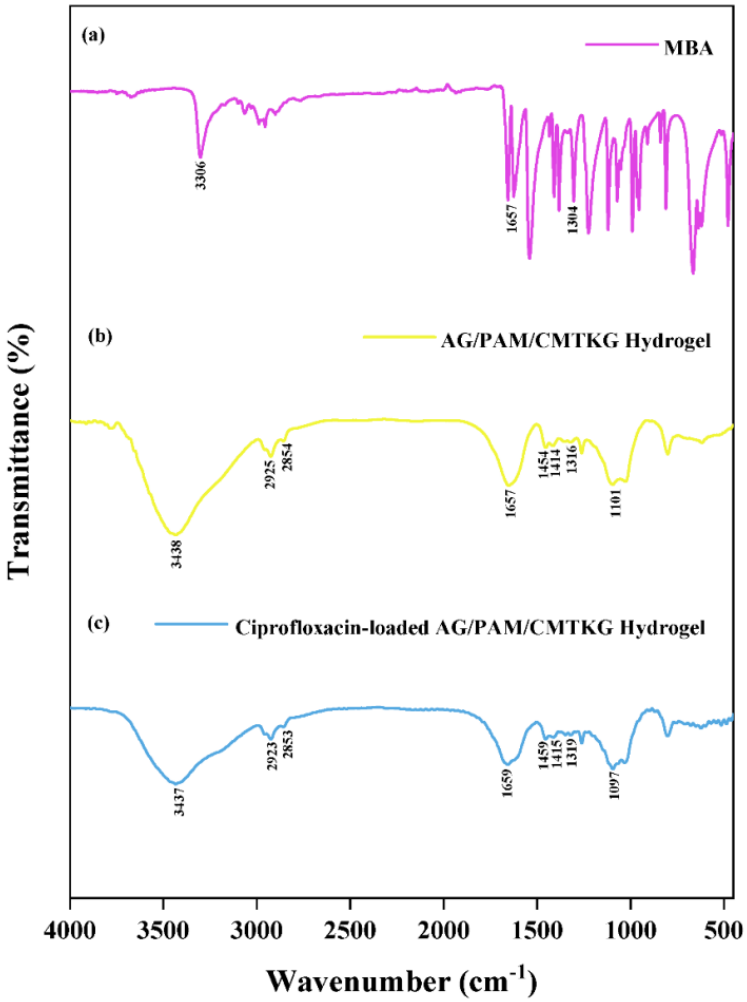


Fig.4.6. ATR-FTIR of MBA, AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel.

4.6.3 SEM

SEM of AG/PAM/CMTKG hydrogel and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel are displayed in Fig. 4.7. The porous and rough surface of the AG/PAM/CMTKG hydrogel indicate large fluid absorption and efficient drug entrapment. Compared to AG/PAM/CMTKG hydrogel, SEM of ciprofloxacin-loaded hydrogel's surface is smoother and less porous because the drug is enclosed within the porous hydrogel matrix.[25].

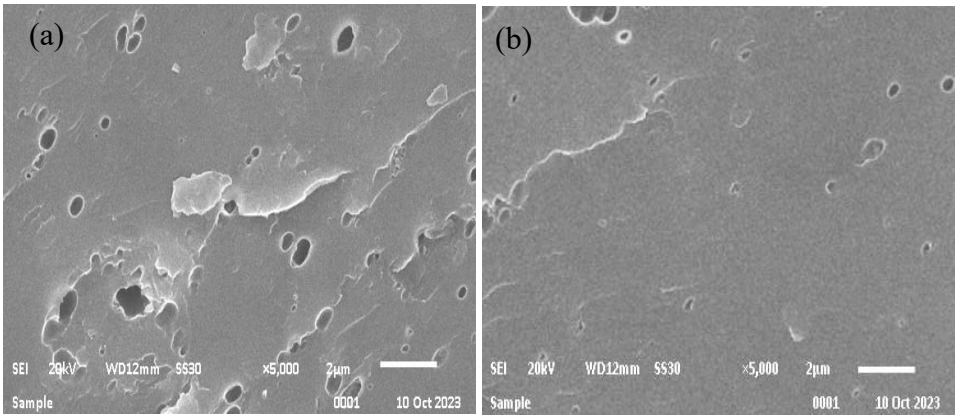


Fig.4.7. SEM of AG/PAM/CMTKG and ciprofloxacin-loaded AG/PAM/CMTKG hydrogel.

CHAPTER 5

CONCLUSION

The pH-responsive ciprofloxacin-loaded AG/PAM/CMTKG hydrogel was fabricated and ciprofloxacin controlled released was successfully studied. The hydrogel was characterized by using the techniques such as PXRD, ATR-FTIR, and SEM. Additionally, the impact of the KPS and MBA amount on the swelling ratio of hydrogel was investigated. At pH 1.2 and 7.4, the in vitro drug release and swelling analysis were carried out, and found to be higher at pH 7.4. According to the results, swelling rises as MBA and KPS content rises, while swelling decreases when KPS amount rises above at a certain point. Ciprofloxacin release kinetics at pH 1.2 and pH 7.4, showed an excellent fit with the Korsmeyer–Peppas model, indicating a Fickian diffusion mechanism at pH 1.2 and a non-Fickian diffusion mechanism at pH 7.4. As a result, it can be concluded that the fabricated AG/PAM/CMTKG hydrogel can be used for the pH-dependent delivery of ciprofloxacin.

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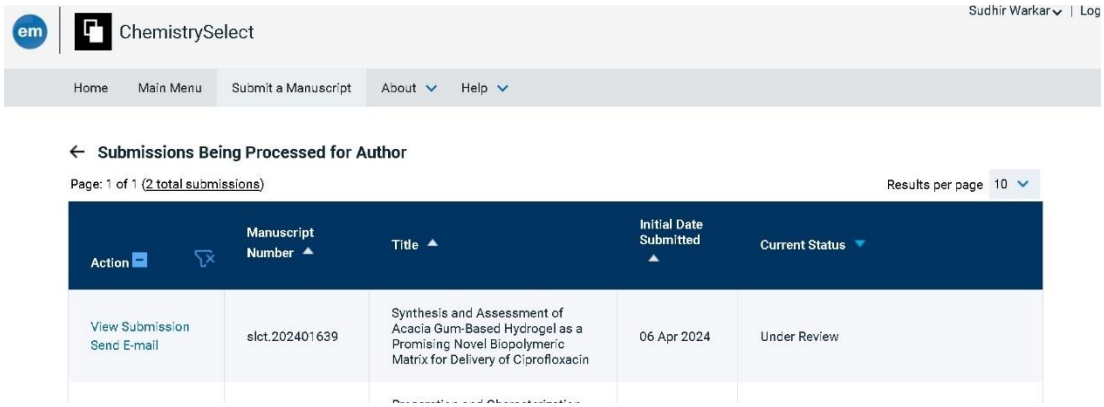

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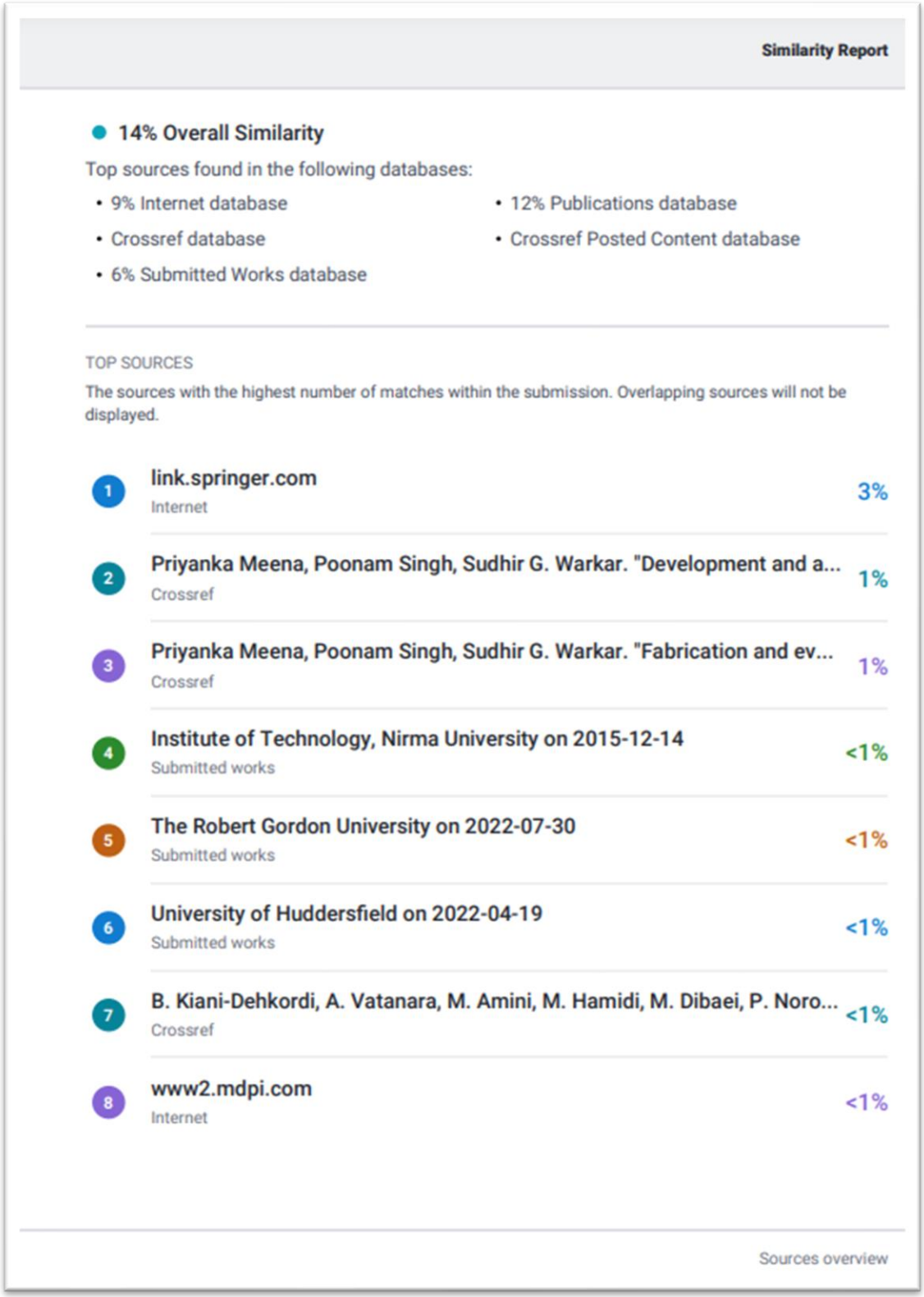

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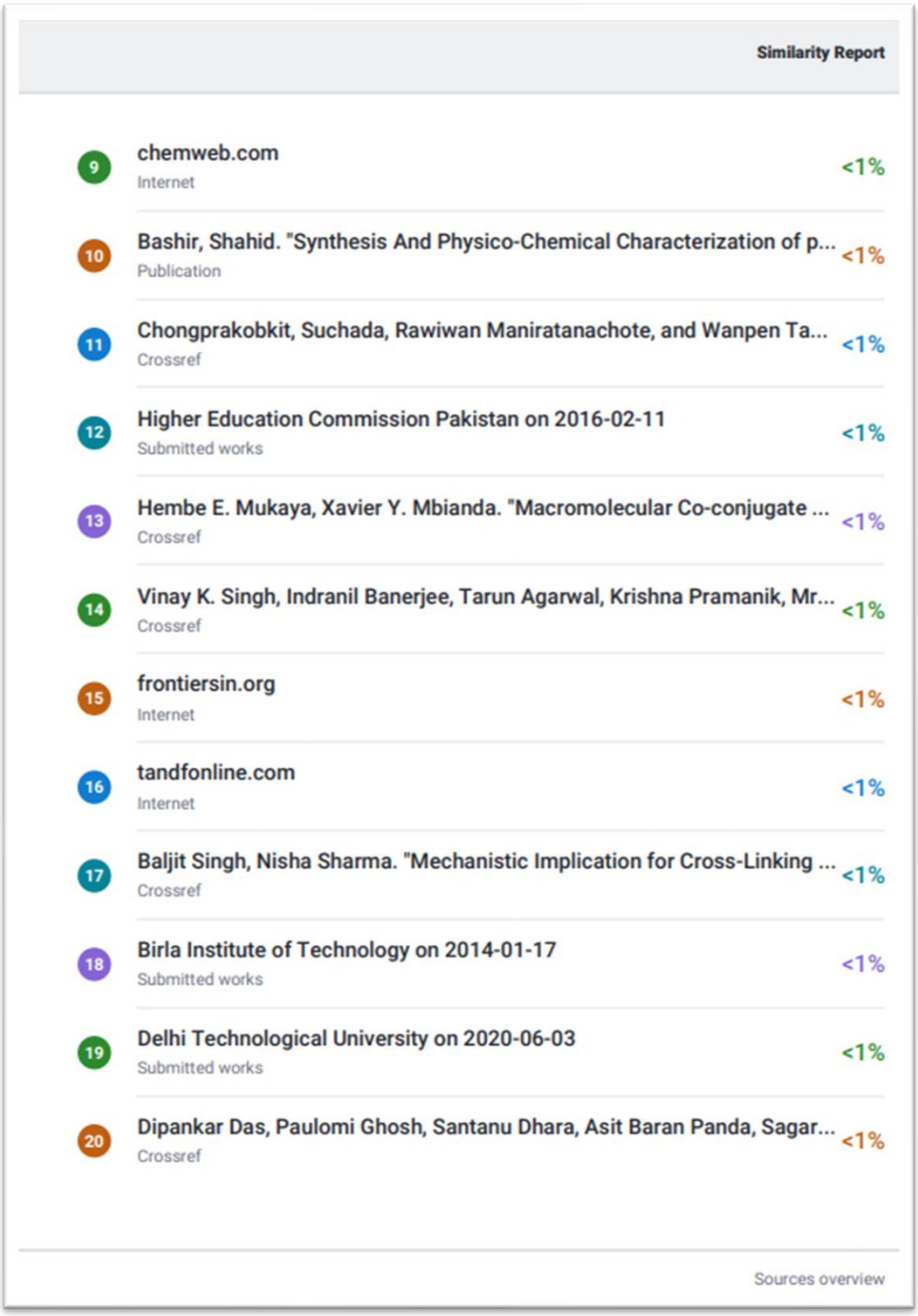

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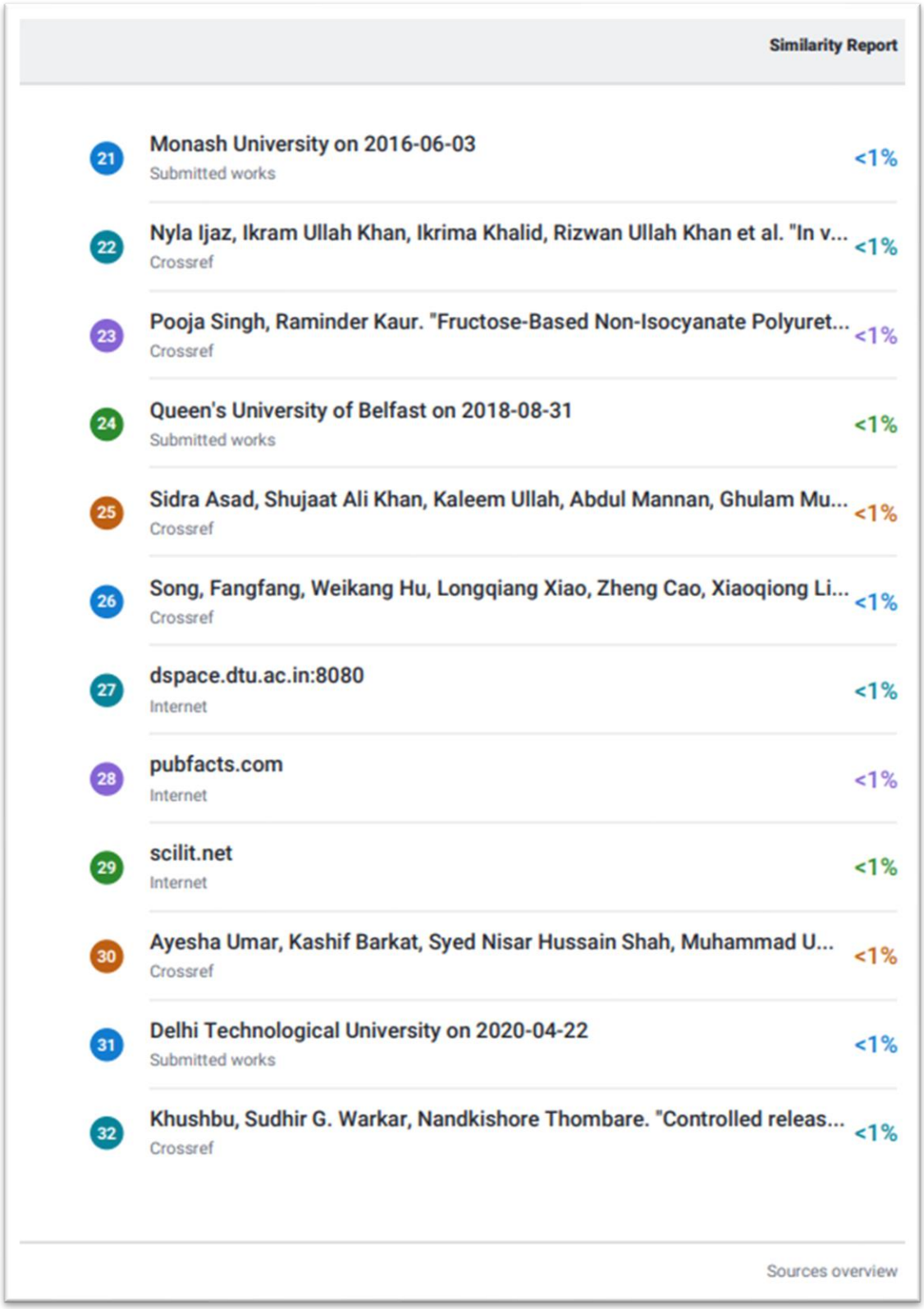

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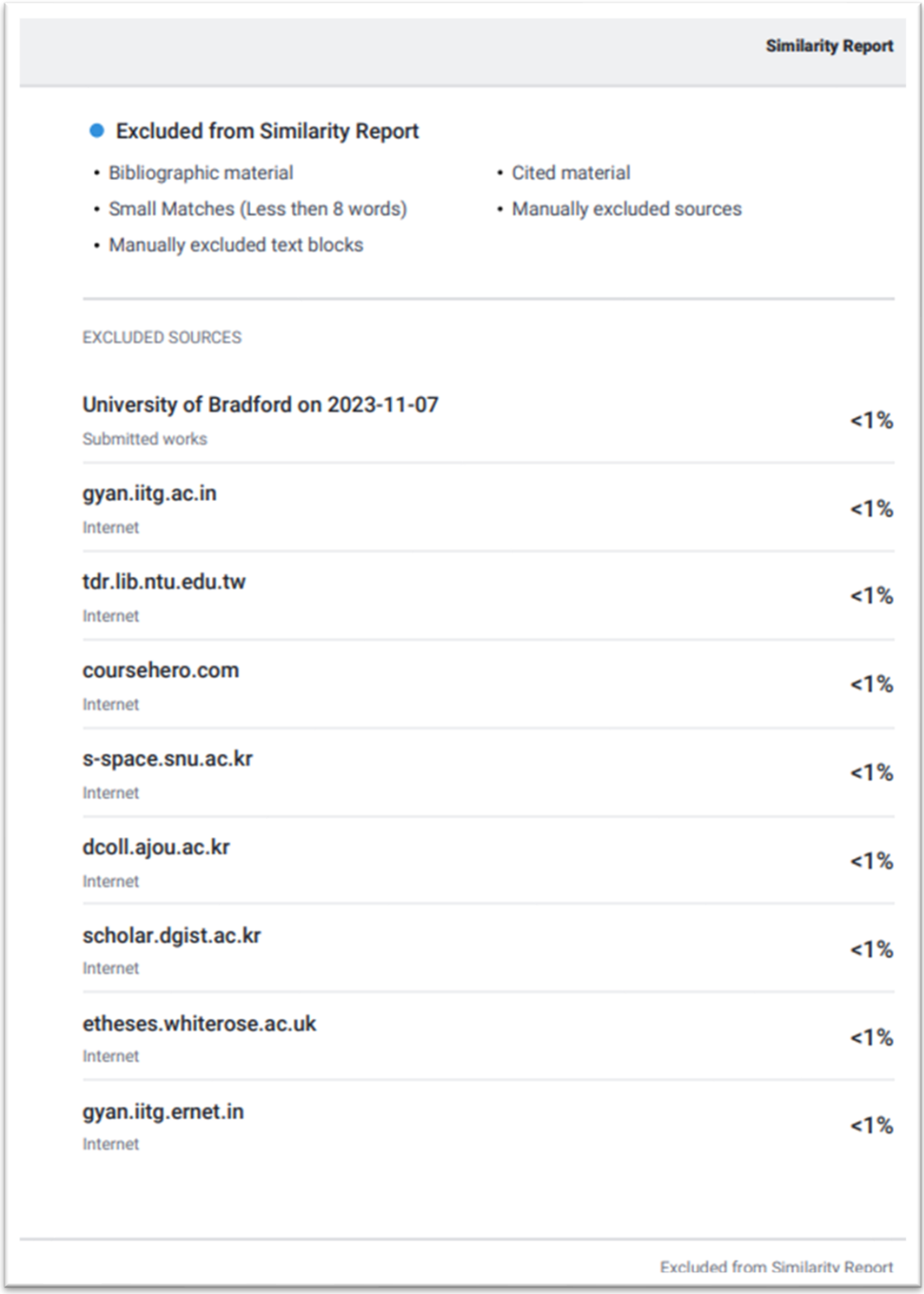

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