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Antimicrobial and Drug Releasing Studies of Novel Acrylate Polymer based on Triazine

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This work is focused on the synthesis and characterization of versatile acrylate polymer of chalcone based triazine for their antibacterial activity and cumulative drug release behaviour studies. The novel acrylate monomer 4-(3-(4-((4-(4-(3-(4-((7-chloroquinolin-4-yl)amino)-phenyl)-3-oxoprop-1-en-1-yl)phenoxy)-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)oxy)phenyl)-3-oxoprop-1-en-1-yl)phenylacrylate (SCP) is from novel chalcone and acryloyl chloride. Homo and copolymers of SCP were prepared using acrylic acid and hydroxyethyl acrylate. Physical characterization confirms the formation of the above compounds. Prepared drug molecules possess chalcone moiety as well as quinoline so it has the greater effect to inhibit the growth of the Gram-negative bacteria (15.63 ± 0.4 µg/mL) was confirmed by MIC method. The weight average molecular weight of the polymer is 10,000 g/mol. The polymer decomposes at 325 ºC. Drug releasing *in vitro* behaviour of the synthesized drug is controlled by the nature of comonomer, pH and the temperature.

Keywords: Quinoline, Chalcone, Acrylate, Polymer, Drug delivery, Antimicrobial activity.

INTRODUCTION

Polymers design containing heterocyclic moiety due to their highly electron-donating and strong coordination abilities receive much special attention because of their applications in the main chain of the polymer backbone [1-3]. Even though huge number of organic molecules reported as a derivatives of triazine. Recently, some of the researchers prepared polymers of triazine and used as flame retardant [4-6], metal adsorption [7], CO_2 capture [8-12], covalent organic edging work [13]. Al-Rasheed *et al*. [14] initially prepared Schiff base of triazine and then converted these into polymer by condensation with terephthaldehyde and revealed excellent thermal properties and excellent limited oxygen indexed values. Zhou *et al*. [15] prepared triazine based polymer using an ethanol and benzo-cyclobutene, which bear excellent thermal stability, excellent packing modulus and excellent dielectric properties. They also concluded that these triazine based polymer have latent use in microelectronic manufacturing as great concert resins. Grate *et al*. [16] reported the side-chain functionalized sequence polymer of cyanuric chloride and concluded that such kind of sequenced polymer is new approach for generating polymer structural design having hydrogen bond or without hydrogen bond for various applications. Several researchers [17-21] also prepared polymer using biologically active molecules like cocoon, chalcone, *etc*. because of vast application in the drug industry .

Chalcones conjugates based on quinoline widely accepted drug molecules and used as antibacterial, antifungal, anticancer, antimalarial, drugs, *etc*. Some of these chalcones can make as polymers and they come under the group of polymeric biocides which means those polymers effectively used as antimicrobial drugs {A-B}. The combination of chalcone, quinoline and triazine enhance the activity of drug molecules [22-26]. Polymer used as drug carrier for slow and steady release of drug molecules, the advantage of the polymeric contains pharmacological activity compounds decreases the toxicological risk [27].

In this article, a chalcone, acrylate monomer and polymer having three active molecules such as quninoline, chalcone and triazine is synthesized and also evaluated for their anti-bacterial activity and cumulative drug release behaviour studies. UV-Visible spectrophotometer was used to monitor the drug releasing pattern of synthesized polymer.

EXPERIMENTAL

4-Hydroxybenzaldehyde, 4,6-dichloroquinoline, (Aldrich Chemicals), 4-nitroaniline, cyanuric chloride, 4-hydroxyacetophenone (HA) and triethylamine (TEA) were procured from S.D. Fine chemicals. Methyl ethyl ketone (MEK), acrylic acid (AA), hydroxyethyl acrylate (HEA) and acryloyl chloride purchased from Merck. 1-(4-(2-Chloroquinolin-5-ylamino)-phenyl)ethanone (CE), 1-(4-(2-chloroquinolin-5-yl-amino)-phenyl)-3-(4-hydroxyphenyl)prop-2-en-1-one (CPE) and 4,6-dichloro-*N*-(4-nitrophenyl)-1,3,5-triazin-2-amine (NTA) were synthesized according to the reported procedure [28,29].

^{1}H NMR of the samples measured using Bruker FT NMR using deuterated DMSO and tetramethylsilane (TMS). Infrared spectrum was measured using Alpha Bruker FT-IR instrument. UV-absorption (LABINDIA model UV 320) used for drug delivery analysis. Thermal response of the synthesized polymer checked using Mettler 3000 thermal analyzers and the Shimadzu instrument using THF as an eluent was used to find the molecular weight. Muller-Hinton agar broth obtained from Himedia for the analysis. *Klebsiella pneumonia* (MTCC3381) and *Escherichia coli* (MTCC739) bacteria brought from the CMC, Vellore, India.

Synthesis of 3-(4-((4-chloro-6-((4-nitrophenoyl)amino)-1,3,5-triazin-2-yl)oxy)phenyl)-1-(4-((7-chloroquinolin4-yl)amino)phenyl)prop-2-en-1-one (NTP): 4,6-Dichloro-*N*-(4-nitrophenyl)-1,3,5-triazin-2-amine (NTA) (0.01 mol) and 1-(4-(2-chloroquinolin-5-yl-amino)phenyl)-3-(4-hydroxyphenyl)-prop-2-en-1-one (CPE) (0.01 mol) were used for the synthesis of NTP and the adopted method was followed [29] (yield: 4.4 g (82%); m.w.: 649; m.p.: 185-186 ºC). IR spectrum shows peak at 3245 represent the presence of N-H *str.*, at 3023 cm^{-1} CH *str.* (aromatic), at 2964 cm^{-1} CH *str.* (aliphatic), 1663 cm^{-1} representing C=O *str.*, at 1603 and 1500 cm^{-1} appears for C=C and Ar-NO_2 *str.*, respectively. Stretching frequency of C-Cl appeared at 1081 cm^{-1}, stretching frequency of 1025 cm^{-1} for C-O-C and *s*-triazine moiety C-N *str.* appears at 812 cm^{-1}. The UV (nm) absorption spectrum reveals two characteristic absorption peaks: 276 and 322 nm, which represented aromatic π-π^* transition and carbonyl n-π^*, respectively. In ^{1}H NMR, appearance of peak at δ 7.3-8.0 ppm is for aromatic hydrogen. The conjugated hydrogen for the group -CO-CH=CH appears at δ 6.6-6.9 ppm. The aromatic NH peak showed at 4.0 ppm.

3-(4-((4-(4-Acetylphenoxy)-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)oxy)phenyl)-1-(4-((7-chloroquinolin-4-yl)prop-2-en-1-one (SAP): NTP (0.005 mol) and 4-hydroxyacetophenone (0.005 mol) taken in a round bottom flask containing acetone and stirred for 6 h at 70 ºC. To this 10% sodium carbonate solution was added drop wise manner to neutralize the formed HCl. Finally, the reaction mass was cooled using ice and thus formed precipitate was filtered and washed using water. Recrystallized product obtained using ethanol. The molecular weight of SAP was 749 g/mol. IR spectrum shows peak at 3305 cm^{-1} represent the presence of N-H *str.*, at 3070 cm^{-1} CH *str.* (aromatic), the peak at 1675 cm^{-1} confirmed the presence of conjugated C=O, at 1593 and 1565 cm^{-1} appears for C=C and Ar-NO_2 *str.*, respectively. Disappearance of peak around at 1080 cm^{-1} confirms the absence of C-Cl in the molecule. The peak at 1028 cm^{-1} is for C-O-C and *s*-triazine moiety C-N stretching appears at 810 cm^{-1}. The UV (nm) absorption spectrum reveals two characteristic absorption peaks: 254 and 336 nm representing aromatic π-π^* and carbonyl n-π^* transition, respectively. In ^{1}H NMR, appearance of peak at δ 7.3-8 ppm is for aromatic hydrogen. The conjugated hydrogen for the group -CO-CH=CH appears at δ 6.8-7.1 ppm. The aromatic NH peak showed at δ 4.1 ppm. The methoxy proton appeared at δ 3.9 ppm.

1-(4-((7-Chloroquinolin-4-yl)-3-(4-((4-(4-(3-(4-hydroxyphenyl)acryloyl)henoxy)-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)oxy)phenyl)prop-2-en-1-one (SCC): SAP (0.025 mol, 16.06 g) and 4-hydroxybenzaldehyde (3.05 g (0.025 mol) were dissolved in ethanol follwed by the addition of 20% NaOH and stirred the reaction mass for 20 h at ambient temperature. The obtained product was neutralized by HCl. The molecular weight of the compound is 853 g/mol. In FT-IR, the peak appears at 3284, 3030, 2985, 1660, 1588, 1549 cm^{-1} representing aromatic OH, aromatic CH, aliphatic CH, carbonyl (C=O), aliphatic CH=CH and Ar-NO_2 *str.*, respectively. *s*-Triazine moiety C-N stretching appears at 810 cm^{-1}. The UV (nm) absorption spectrum reveals three characteristic absorption peaks: 254, 320 and 345 nm representing aromatic π-π^* and two carbonyl n-π^* transition, respectively. In ^{1}H NMR, appearance of peak around δ 6.5 to 8.3 ppm is for aromatic and vinylic hydrogen. The aromatic NH peak showed at δ 3.9 ppm. The absence of peak at δ 3.9 (-OCH_3) and the appearance of peak at δ 5.5 (Ar-OH) confirms the formation of the product.

Synthesis of 4-(3-(4-((4-(4-(3-(4-((7-chloroquinolin-4-yl)amino)phenyl)-3-oxoprop-1-en-1-yl)phenoxy)-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)oxy)phenyl)-3-oxoprop-1-en-1-yl)phenyl acrylate (SCP): SCC (0.01 mol) in 150 mL of MEK, TEA (0.012 mol) was added and stirred mechanically at 0-5 ºC followed by the addition of 0.012 mol of acryloyl chloride dissolved in 30 mL of MEK were added dropwise to the reaction mixture with constant stirring with the help of pressure equalizing addition funnel. The solid triethyamine hydrochloride salt was removed by filtration and the crude acrylate derivative was obtained by solvent evaporation (molecular weight was 923 g/mol). In FT-IR, the peaks were appears at 3371 (Ar-NH *str.*), 3057 (aromatic CH-0.012 *str.*), 2988 (aliphatic -CH *str.*), 1724 (-C=O of ester), 1676 (C=O *str.*), 1588 (CH=CH *str.*), 1540 (Ar-NO_2 *str.*), 1097 (C-Cl *str.*) and 811 (C-N *str.*). The UV (nm) absorption spectrum reveals two characteristic absorption peaks: 226 and 334 nm representing aromatic and π-π^* and carbonyl n-π^* transition, respectively. In ^{1}H NMR, appearance of peak around δ 6.9 to 8.3 ppm is for aromatic and vinylic hydrogen. The polymerizable vinylic protons (3H) is appeared at δ 5.9-6.4 ppm confirms the formation of the acrylate derivative. The aromatic NH peak showed at δ 3.9 ppm.

Synthesis of poly(SCP): SCP (1.0 g) and benzoyl peroxide (BPO) (0.03 g, 3 wt.%) were taken in a polymerization tube having 10 mL of MEK, degassed, heated at 70 ± 1 ºC in a thermostated water bath for 24 h. The poly(SCP) was precipitated using methanol. In FT-IR, the peaks appears at 3295,

3043, 2990, 1749, 1628, 1610, 1554, 1099, 812 cm^{-1} represents NH proton, aromatic CH *str.*, aliphatic CH *str.*, ester C=O, free C=O, CH=CH, aromatic NO_2, C-Cl and C-N *str.*, respectively. The UV (nm) absorption spectrum reveals three characteristic absorption peaks: 246, 264 and 328 nm representing two aromatic π to π^* and *n* to π^* transition, respectively. In ^{1}H NMR (δ, ppm), the peak appears at 6.7-8.0 (m), is associated with the aromatic and vinylic type protons. The aromatic NH peak showed at δ 4.3 ppm. The cluster of peak around δ 0.9-1.7 ppm is due to alkane protons confirm the formation of the polymer from the monomer.

Preparation of copolymer: The synthesis of copolymer was performed according to the reported method [28]. Equimolar ratios of the monomer 1 and the monomer 2 were used for the copolymer preparation.

Synthesis of poly(SCP-*co*-AA): SCP (1.38 g) and acrylic acid (AA, 0.28 g), MEK (10 mL) and 0.02 g of BPO were employed for the preparation of poly(SCP-*co*-AA) (yield: 0.88 g). In FT-IR, the peak appears at 3400 cm^{-1} for -OH. The peak at 3095 and 2927 cm^{-1} corresponds to the CH stretching of aliphatic and aromatic, respectively. The peak at 1710 cm^{-1} attributes for ester C=O and at 1655 cm^{-1} for free C=O. Aromatic CH=CH *str*. appears at 1596 cm^{-1}. The UV (nm) absorption spectrum reveals two characteristic absorption peaks: 260 and 330 nm representing aromatic π-π^* and n-π^* transition, respectively. In ^{1}H NMR, the acidic proton appears at 10.7 ppm and the peak appears at δ 7.0-8.4 ppm is associated with the aromatic and vinylic type protons. The aromatic NH peak showed at δ 4.3 ppm. The cluster of peak around δ 1.0-1.7 ppm is due to alkane protons confirmed the formation of the polymer from the monomers.

Synthesis of poly(SCP-*co*-HEA): SCP (1.38 g) and hydroxyethyl acrylate (HEA, 0.46 g), MEK (10 mL) and 0.02 g of BPO were employed for the preparation of poly(SCP-*co*-HEA). (yield: 1 g). In FT-IR, the broad peak appears at 3413 cm^{-1} for OH. The peak at 3040 and 2939 cm^{-1} corresponds to the -CH stretching of aliphatic and aromatic analogues, respectively. The peak at 1729 cm^{-1} attributed for ester C=O, 1682 cm^{-1} for free C=O. Aromatic CH=CH stretching appears at 1596 cm^{-1}. The UV (nm) absorption spectrum reveals two characteristic absorption peaks: 264 and 340 nm representing aromatic π-π^* and n-π^* transition, respectively. In ^{1}H NMR, the peak appears at δ 6.9-8.5 ppm is associated with the aromatic and vinylic type protons. The hydroxyl proton appears at δ 4.5 and NH peak showed at δ 4.3 ppm. The cluster of peak around δ 0.9-1.6 ppm is due to alkane protons confirmed the formation of the polymer from the monomer.

Antibacterial activity and *in vitro* drug release study: The monomer and polymer showed the promising result in the preliminary screening method *i.e.* disc-diffusion test (inhibition zone > 10 mm) have been further evaluated by the minimum inhibitory concentration (MIC) method. The compounds were tested against two microbes namely, *Klebsiella pneumonia* (MTCC3381) and *Escherichia coli* (MTCC739). MIC values using turbidity method [28]. Unpaired student's *t*-test was apllied to get the statistical analysis. The reported procedure was adopted for film making and *in vitro* drug release experiments in this study also [28].

RESULTS AND DISCUSSION

Novel chalcone 1-(4-((7-chloroquinolin-4-yl)-3-(4-((4-(4-(3-(4-hydroxyphenyl)acryloyl)phenoxy)-6-((4-nitrophenyl)-amino)-1,3,5-triazin-2-yl)oxy)phenyl)prop-2-en-1-one (SCC) and the monomer 4-(3-(4-((4-(4-(3-(4-((7-chloroquinolin-4-yl)amino)phenyl)-3-oxoprop-1-en-1-yl)phenoxy)-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)oxy)phenyl)-3-oxoprop-1-en-1-yl)phenyl acrylate (SCP) were synthesized and characterized by IR, UV and ^{1}H NMR techniques (**Schemes I** and **II**). Monomer SCP, homo-polymer, poly(SCP) and the copolymer, poly(SCP-*co*-AA) and poly(SCP-*co*-HEA) were prepared as given in the **Schemes III** and **IV**, respectively.

The solubility of the polymer is shown in Table-1. The monomer SCP is soluble in all polar solvents including methanol. The solubility of the monomer in methanol provides unique advantage to prepare very pure polymer during the polymerization process. This is due to the fact that the polymer is precipitated in the methanol and during this process, the unreacted monomer is dissolved in the methanol and the pure polymer is precipitated out from the reaction mixture. The synthesized polymers are freely soluble in DMSO, DMF and THF and not soluble in water, methanol and chloroform. However, the polymers are partially soluble in ethanol. The copolymer was also found to be insoluble in the non-polar solvents such as benzene, *n*-hexane and carbon tetrachloride.

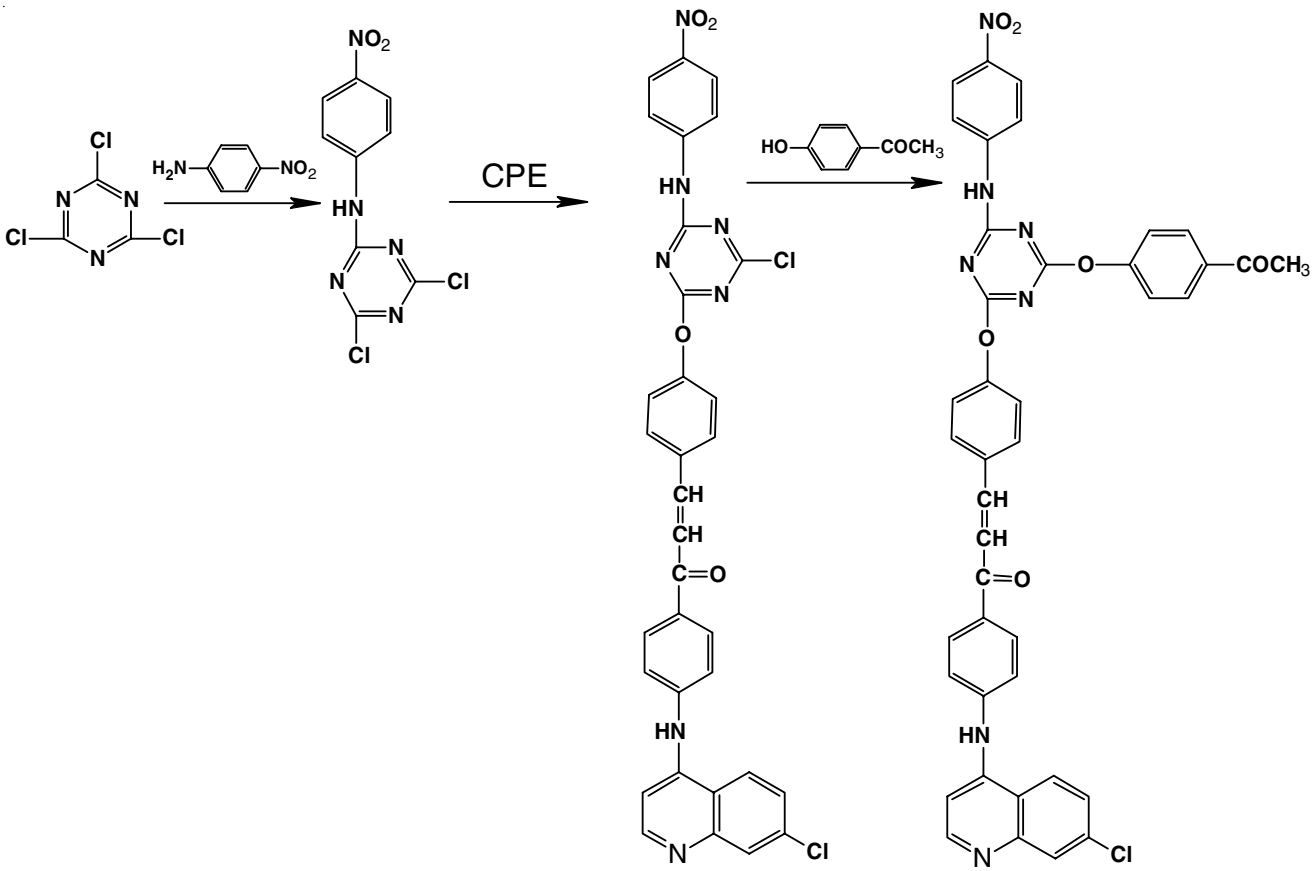
Molecular weights of homo and copolymer: Gel permeation chromatography (GPC) was used for determining the molecular weight of the prepared homo and copolymers based on the acrylate SCP. The weight (M_w) and number average molecular weight (M_n) and the polydispersity (M_w/M_n) of the synthesized homo-polymer poly(SCP) was $M_w = 8.62 \times 10^3$, $M_n = 4.88 \times 10^3$ and 1.77, respectively. This predicted trend *i.e.*, M_w values of around 10000 have been observed for other synthesized polymer system and the obtained values given in Table-2. Polydispersity index which is less than 2, indicates that the termination process by inequity method, which was emblematic of acrylate.

Thermal analysis: Fig. 1 shows the TGA and DTA thermogram of poly(SCP). The polymer decomposes in a single stage

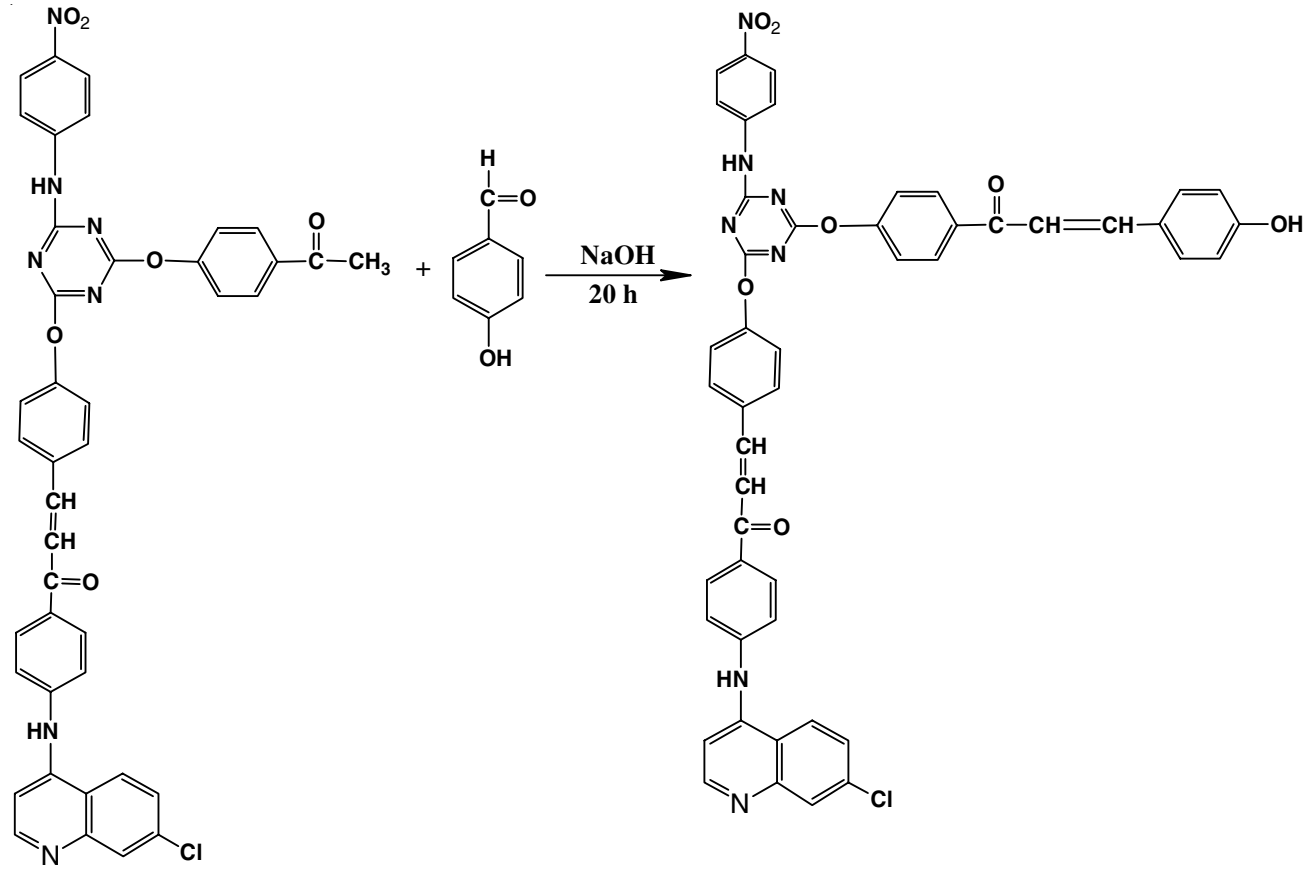
TABLE-1
SOLUBILITY DATA OF THE SCP MONOMERS AND ITS POLYMERS

Sample name	H_2O	MeOH	EtOH	CCl_4	$CHCl_3$	DMSO	DMF	Acetone	C_6H_6	THF	*n*-Hexane
SCP	–	+	+	±	+	+	+	+	±	+	–
Poly (SCP)	–	–	±	–	–	+	+	±	–	+	–
Poly(SCP-co-AA)	–	–	–	–	±	+	+	–	–	+	–
Poly(SCP-co-HEA)	–	–	–	–	–	+	+	–	–	+	–

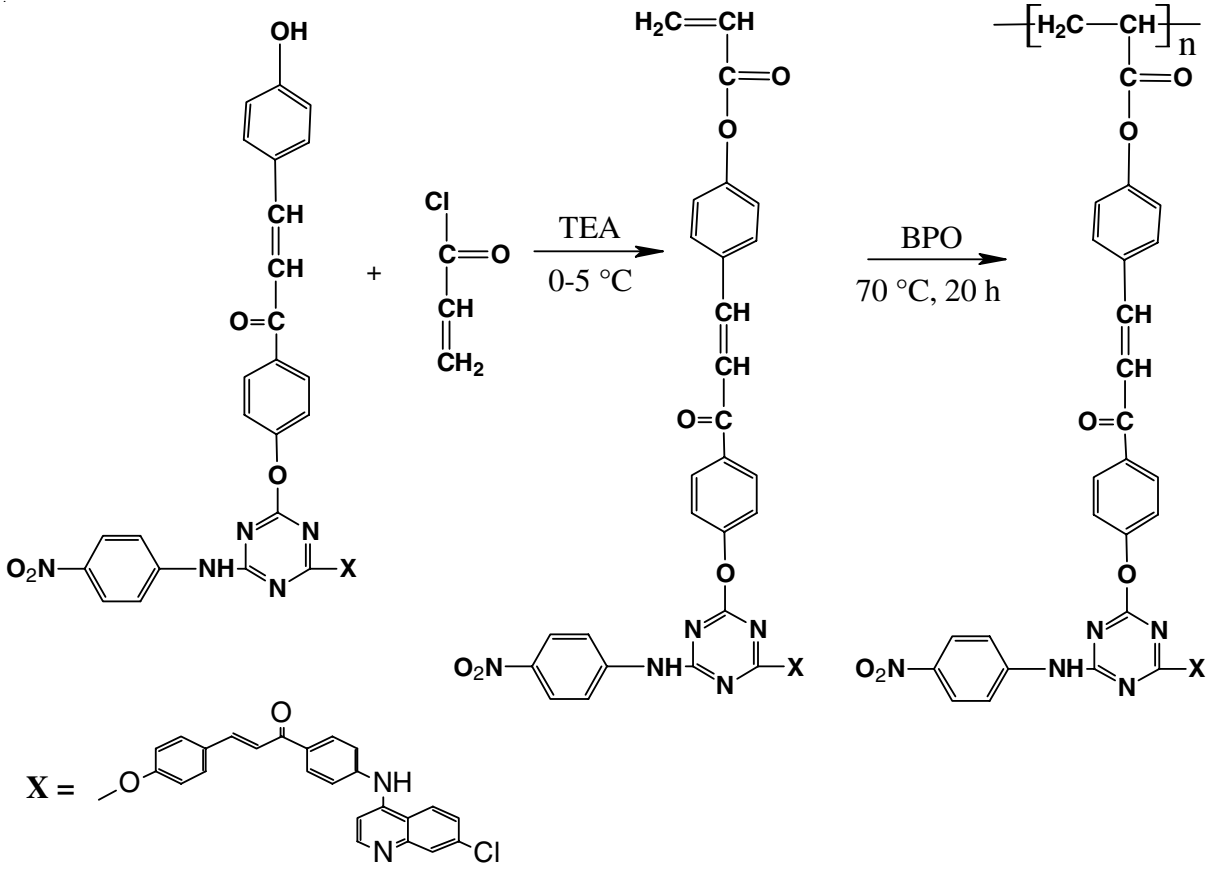
+ = Soluble, – = Insoluble and ± = Partially soluble



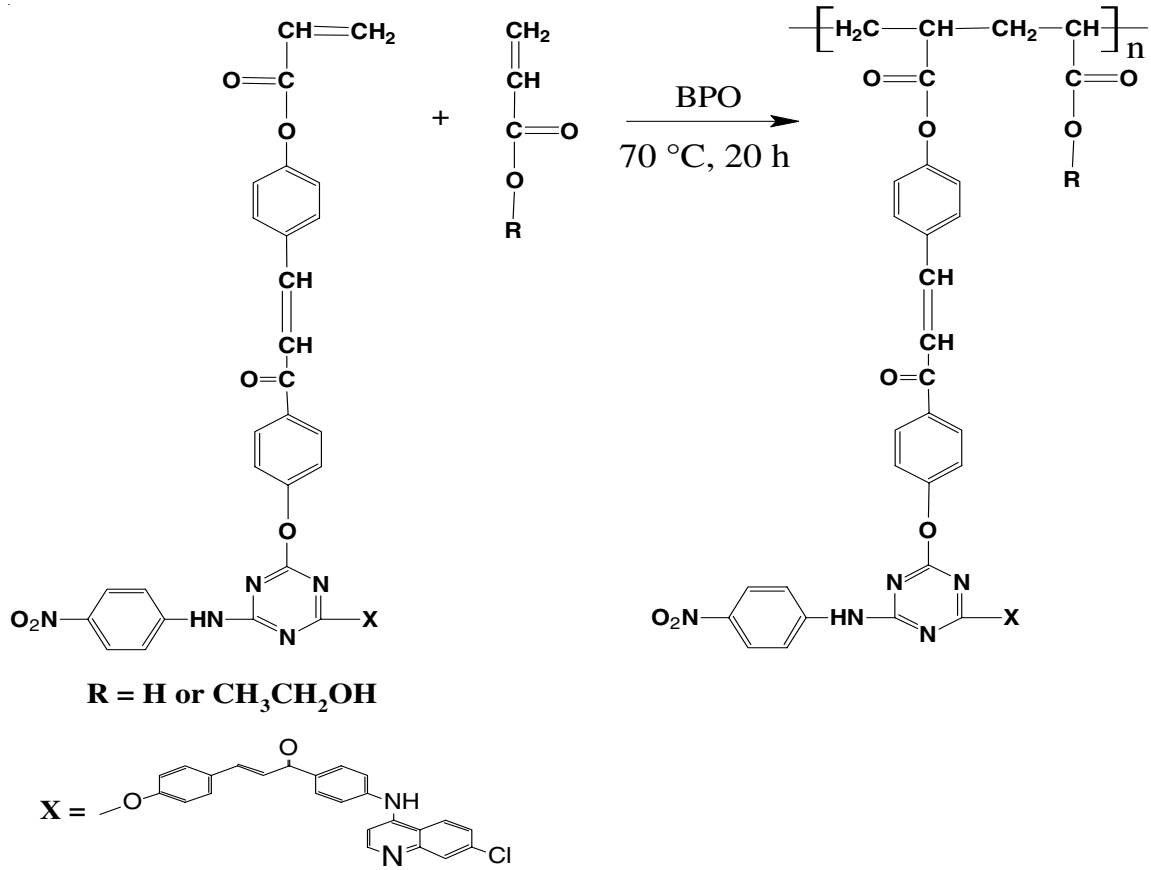
Scheme-I: Synthesis of SAP



Scheme-II: Synthesis of SCC



Scheme-III: Synthesis of SCP and poly(SCP)



Scheme-IV: Synthesis of poly(SCP-*co*-AA) and poly(SCP-*co*-HEA)

TABLE-2
TGA, MOLECULAR WEIGHT DATA OF THE SCP POLYMERS

Polymer code	TGA	Molecular weight		
	Decom-position temp. (°C)	$M_n \times 10^3$ (g/mol)	$M_w \times 10^3$ (g/mol)	M_w/M_n
Poly(SCP)	330	4.88	8.62	1.77
Poly(SCP-*co*-AA)	318	4.23	7.91	1.86
Poly(SCP-*co*-HEA)	315	5.21	9.35	1.79

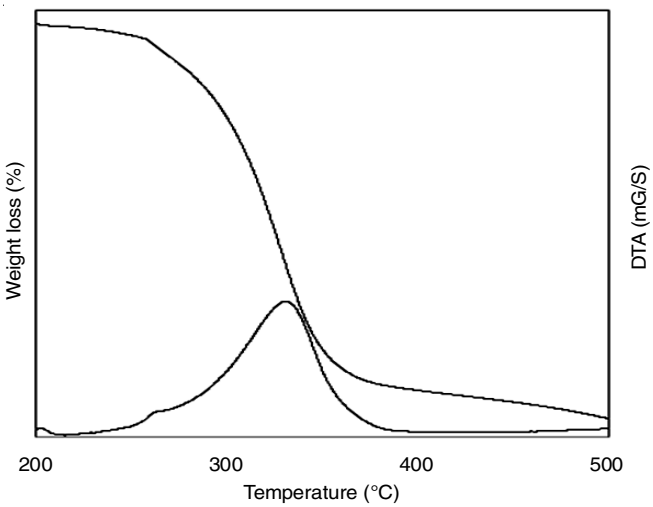


Fig. 1. Thermogravimetric and DTA curves of poly(SCP)

and the decomposition temperature centered on at 330 ºC. Similar to the homopolymer, the synthesized copolymer also showed a single stage decomposition and the values are shown in Table-2. Both homo and copolymer of the polymer was thermally stable and the decomposition temperature revolves around 300 ºC.

Antimicrobial activity: Table-3 shows the triplicate MIC values of the monomer SCP, poly(SCP), poly(SCP-*co*-AA) and poly(SCP-*co*-HEA). Antimicrobial activity of the synthesized monomer and its polymer are shown in Fig. 2. Hydrophilic comonomer is highly responsible for the antimicrobial activity on the Gram-negative stain bacteria. The antibacterial activity of copolymer having acrylic acid is high on both *Klebsiella pneumonia* and *Escherichia coli* bacteria as like oxazolidinone class of compound. Exactly same activity on both the bacteria not at all found, this might be due to variation in the cell wall composition of bacteria. Activity on *Escherichia coli* is high for the synthesized polymer than the monomer SCP. The MIC value of poly(SCP-*co*-AA) on *Escherichia coli* was found to be high (15.63 ± 0.5 µg/mL).

TABLE-3
MIC VALUES OF SCP, POLY(SCP),
POLY(SCP-CO-AA) AND POLY(SCP-co-HEA)

Polymer code	MIC value (µg/mL)	
	Escherichia coli	*Klebsiella pneumoniae*
SCP	64.5 ± 0.81	66.3 ± 2.3
Poly(SCP)	63.5 ± 1.5	122 ± 5.7
Poly(SCP-*co*-AA)	15.63 ± 0.44	31.25 ± 1
Poly(SCP-*co*-HEA)	60.5 ± 4.4	62.5 ± 1.2
Amoxicillin	15.11 ± 1.30	14.2 ± 0.9

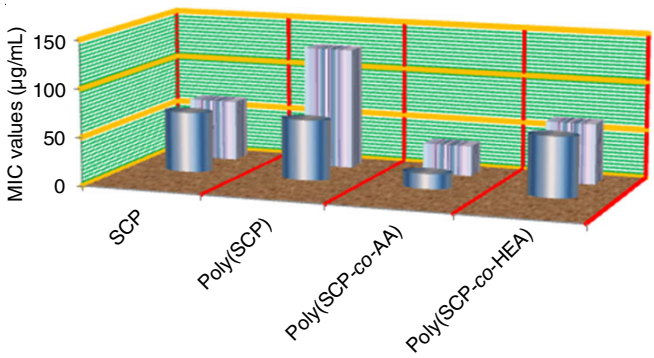


Fig. 2. Comparative MIC graph of SCP, poly(SCP), poly(SCP-*co*-AA) and poly(SCP-*co*-HEA) on Gram-negative bacteria [cylinder = *Escherichia coli* (E.c.) and colum = *Klebsiella pneumoniae* (K.p.)]

The presence of acrylic acid in copolymer is not alone reason for the antibacterial activity because poly(AA) exhibit no antibacterial activity, the presence of SCP monomer is highly responsible for the antibacterial activity of poly(SCP-*co*-AA) on the tested bacteria. The antimicrobial activity enhancement of poly(SCP-*co*-AA) over poly(SCP) on *Klebsiella pneumonia* and *Escherichia coli* was due to the ease of use of active drug moiety (SCP) nearby to the bacteria cell wall and/or the opening up of the cell wall [27]. The presence of acrylic acid (AA) in copolymer enhance the acidic nature of medium is also responsible to penetrate the cell wall of bacteria.

Effect of comonomer on Gram-negative bacteria: Polymer containing comonomer acrylic acid shows high activity on Gram-negative bacteria than the polymer having hydroxyethyl acrylate (HEA) as comonomer. Here, the ionic strength plays a vital role on antibacterial activity, AA increase the ionic strength whereas HEA fails. Besides this, AA has an ability to participate in the detachment of active drug from the polymer chain through neighbouring group participation mec-hanism. Therefore, poly(SCP-*co*-AA) was found to be active compared to other polymers such as a poly(SCP) and poly(SCP-*co*-HEA) towards the Gram-negative bacteria.

Control release studies of copolymers: Figs. 3 and 4 show the drug releasing behaviour of the polymer samples poly(SCP-*co*-AA) and poly(SCP-*co*-HEA), respectively. Two factors have been varied to study the releasing behaviour namely, temperature (37 and 40 ºC) and pH (7.4 and 9.2). The studied polymers drug releasing shows that the releasing of the drug from the polymer backbone follows Fickian model. According to this model, the initial drug release by bursting effect followed by the plateau region. Also, as it was predicted from the literature, more drugs have been released from the polymer when the pH of the medium changes from 7.4 to 9.2 [28]. This is due to the resistance to hydrolysis provided by the ester linkage at lower pH value. In all the cases, the releasing pattern shows an irregular drug releasing behaviour. This type of release comes under the Fickian type release or bursting effect and can be overcome by changing the sample shape from film to granular type [29]. However, the present study dealing with the studying the effect of temperature, we stick to the film shape rather than the granular type. In relatively acidic medium *i.e.*, 7.4 compared to 9.2, ether linkage showed more

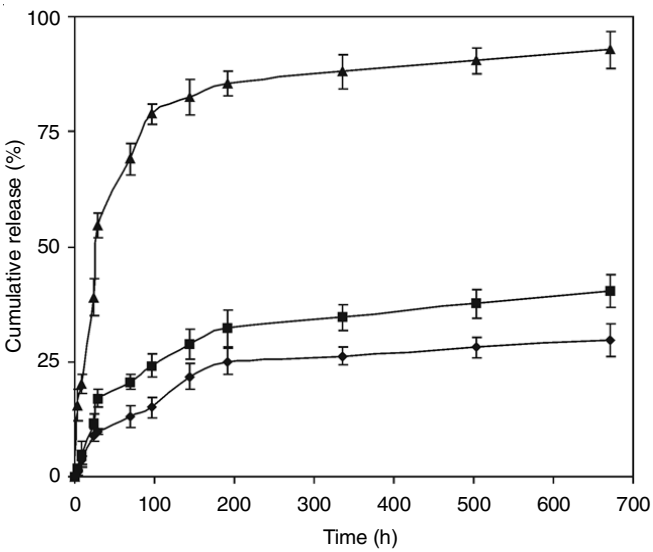


Fig. 3. Effect of pH and temperature (◆ = pH 9.2 at 37 ºC, ▲ = pH 7.4 at 40 ºC and ■ = pH 7.4 at 37 ºC) on drug releasing rate of poly(SCP-*co*-AA) (average ± S.D., n = 3)

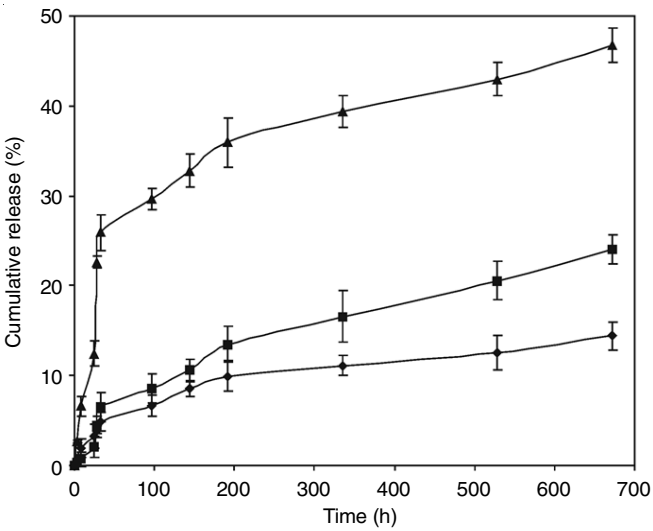


Fig. 4. Effect of pH and temperature (◆ = pH 9.2 at 37 ºC, ▲ = pH 7.4 at 40 ºC and ■ = pH 7.4 at 37 ºC) on drug releasing rate of poly(SCP-*co*-HEA) (average ± S.D., n = 3)

resistance to release active drug moiety to the surrounding [30,31]. The other factor, presence of aromatic system also enhances the drug releasing rate [32]. Regarding the effect of temperature, when the temperature changes from 37 to 40 ºC, the drug releasing rate increases due to increase in the chain mobility which allows the water molecules to penetrate through the polymer chain. This effect is pronounced in the film form of the polymer rather than granular type. This unique pattern of drug release is finds important application in intestine infections [33].

A comparative drug releasing graph between poly(SCP-*co*-AA) and poly(SCP-*co*-HEA) is shown in Fig. 5, which concluded that copolymer bearing acrylic acid as a comonomer showed much faster drug release than HEA and this behaviour may be due to the neighbouring group participating mechanism provided by the acrylic acid towards hydrolysis [34,35].

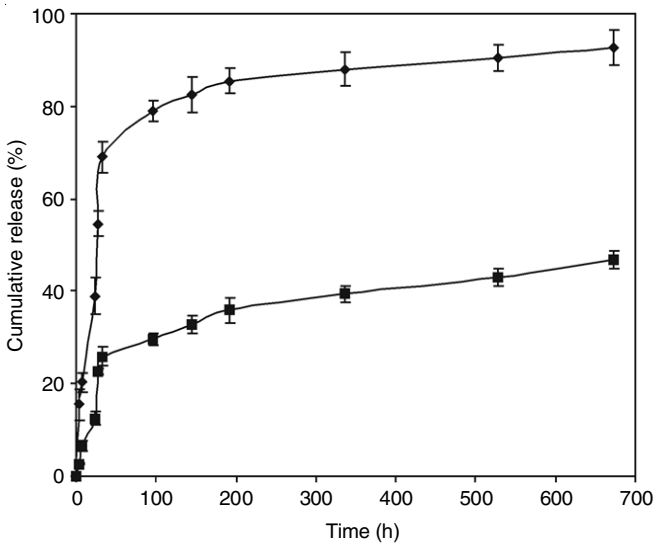


Fig. 5. Effect of comonomer type (◆ = AA, ■ = HEA) on the drug releasing rate from the polymer film of SCP type polymer (pH 9.2 at 37 ºC) (average ± S.D., n = 3)

Conclusion

Novel chalcone based on cyanuric chloride derivative of quinoline (SCC) and its acrylate monomer (SCP) were synthesized and characterized. Synthesized SCP acrylate monomer was converted into homo-polymer and copolymer by using SCP monomer and acrylic acid (AA) and hydroxylethyl acrylate (HEA) monomer through solution polymerization technique. Synthesized polymers were characterized using UV-Visible, ^{1}H-NMR, FT-IR techniques and thermal analysis of the polymer were thermally stable up to 300 ºC. The conversion of monomer into polymer was confirmed by ^{1}H NMR and FT-IR spectroscopic technique, the polymerizable vinylic proton peaks disappeared in NMR spectrum and the vinyl stretching frequency not shown in FT-IR spectrum of synthesized polymers. Formed polymers have molecular weights of around 10000 g/mol confirmed by GPC technique. Antimicrobial activity of the four compounds [SCP, poly(SCP), poly(SCP-*co*-AA) and poly(SCP-co-HEA)] were tested on *Escherichia coli* and *Klebsiella pneumonia.* Excellent antibacterial activity shows by entire compound due to the presence of hetero cyclic ring of triazine, quinoline and their chalcone moiety in the synthesized molecule. Copolymers displayed high activity against tested Gram-negative bacteria namely, *Escherichia coli*. Drug releasing pattern of the polymer was monitor for 4 weeks and the results concluded that the drug release is greatly influenced by the comonomer type, pH and the temperature of the medium. Chalcone drug releasing through polymer film was high at high temperature. Overall, the synthesized compounds having pleasing biological activity could be used as controlled drug delivery.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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