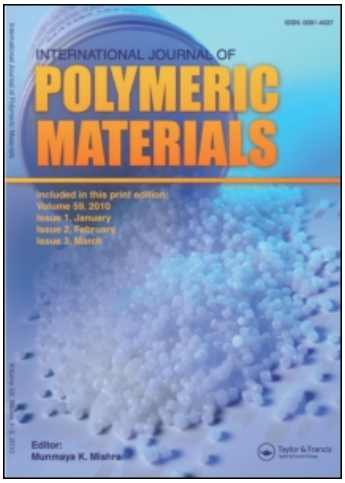

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Sustained Release of Metoprolol Tartarate from Radiation-Grafted pH-Responsive Hydrogels

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pH-responsive hydrogels composed of methacrylic acid (MAA) grafted on poly (ethylene oxide)-poly(vinylpyrrolidone)(PEO-PVP) network were made by electron beam irradiation technique. The grafting was carried out at various concentrations of MAA with different irradiation doses. The gels were characterized by IR, DSC and SEM techniques. The swelling behavior of the gels was studied under different pH conditions. The swelling parameters were evaluated. The mode of water diffusion into the gels was found to be structure-dependent. The pH responsiveness of the gels was evident from the enhanced swelling of the gels with increasing pH of the medium. The suitability of these gels as matrix materials for stimuli-responsive sustained-release drug formulations was studied. The in vitro release profile of an antihypertensive drug, metoprolol tartarate, from these gels was studied at pH 1.2 and 7.4. The extent of drug release is found to be pH-dependent. The data were analyzed to understand the mechanism of drug release from the gels. The gels exhibited diffusion-controlled release behavior. Drug release kinetic analysis indicated "first order" release where the amount of drug released is dependent on the matrix drug load and the value of the diffusion coefficient indicated anomalous diffusion.

Keywords: diffusion controlled, electron beam irradiation, grafting, hydrogel, pH sensitivity, release kinetics, sustained release

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INTRODUCTION

Hydrogels are three-dimensional networks of hydrophilic polymers obtained by physical or chemical crosslinking of the polymer chains. They possess the ability to absorb large amounts of water while retaining the three-dimensional structure, and find extensive use in medical, pharmaceutical, agricultural and industrial fields [1–3]. "Stimuli-responsive hydrogels" refers to a special class of hydrogels which exhibit dramatic changes in their physical or chemical behavior in response to slight variations in external conditions such as temperature, ionic strength or pH of the medium. Intensive studies are being carried out on the development of these hydrogel materials, especially for biomedical or pharmaceutical applications [4–6]. It has been well-established that the incorporation of ionizable pendant groups on the polymeric backbone enables reversible structural changes in the network, dependent on pH. Hydrogels of ionic polymers such as poly(acrylic acid) [7], poly(itaconic acid) [8], poly(maleic acid) [9], poly (methacrylic acid) [10] have been most commonly studied for pH-responsive behavior. Copolymers of poly(ethylene oxide) [11], poly (vinyl pyrrolidone) [12] and poly(vinyl alcohol) [13], with various ionic monomers such as itaconic acid, methacrylic acid and acrylic acid, have been made and used in the design of intelligent controlled-release devices for site-specific drug delivery of therapeutic drugs or proteins to the gastrointestinal tract, where the biological activity of the drugs or proteins is prolonged. The change in the pH of the external environment acts as a stimulus in response to which the swelling properties of the hydrogels change, causing the release of the drug or protein.

Research on the use of radiation in the production of hydrogels has become intense during the last two decades [14–17]. Numerous applications have been envisioned for these materials, particularly in the biomedical area. Some special use areas of hydrogels are wound dressing, soft contact lenses, controlled-released drug delivery systems, biocompatibility, artificial skin, water absorbents, and adsorbents for metal ions or enzymes for purification or catalysis applications [18–23].

In the present paper, the preparation of a MAA-grafted interpenetrating network system of two hydrophilic polymers namely, PVP and PEO, by electron beam irradiation technique is reported. The conditions of preparation to obtain mechanically stable gels with the required level of grafting have been optimized. The gels have been characterized for their structure and their swelling behavior. The suitability of these gels as matrix materials for the sustained release of the drug metoprolol tartarate (MT) has been evaluated.

EXPERIMENTAL

Materials

Poly(vinyl pyrrolidone)(PVP) of molecular weight 40,000 was purchased from Central Drug House Pvt. Ltd., New Delhi, India. Poly(ethylene oxide) (PEO) of molecular weight 6,000 was obtained from Ranbaxy-Laboratories Ltd., S.A.S. Nagar, India. Methacrylic acid (MAA) was obtained from Merck Ltd., Mumbai, India. Ammonium ferrous sulphate (AFS) was supplied by S.D. Fine Chemicals, Mumbai, India. The drug metoprolol tartarate (MT) was obtained as a gift sample from Astra Zeneca, Bangalore, India. All other reagents were of analytical grade. Doubly distilled water was used in the preparation of hydrogels and for swelling studies.

Radiation Synthesis of PEO-PVP Hydrogels

Binary mixtures of PVP and PEO (1:1) of total polymer concentration 16% (w/v) were made in distilled water at room temperature. These mixtures were taken in plastic vials and irradiated with an electron beam of energy 8.3 MeV with a dose rate of 1 kGy/min. The total dose given was 100 kGy. The hydrogels obtained on irradiation were washed with water and dried at 50°C under vacuum to constant weight.

Preparation of MAA-grafted PEO-PVP Hydrogels

Dried PEO-PVP hydrogels of known amounts were allowed to swell in an aqueous solution of MAA (30 and 50% w/v) containing 0.01 M ammonium ferrous sulphate for 12 h. The swollen gels were placed in plastic vials and irradiated again with an electron beam. The total dose of irradiation was in the range 5–15 kGy. The grafted gels were washed repeatedly with water and dried at 50°C under vacuum. The details of the preparation conditions of hydrogels are listed in Table 1.

FTIR Analysis

FTIR spectra of PVP-PEO and MAA-grafted PVP-PEO hydrogels were recorded on a Nicolet Avatar 330 FTIR spectrophotometer using a silicon carbide disc.

Scanning Electron Microscopic (SEM) Analysis

The SEM analysis of the PVP-PEO hydrogels, prior to and after grafting with MAA, was carried out with a JEOL-JSM 5800LV scanning

TABLE 1 Details of Preparation Conditions for Grafting of Hydrogels

Formulation code	MAA conc.(%)	Dose (kGy)
PPM 1	30	5
PPM 2	30	10
PPM 3	30	15
PPM 4	50	5
PPM 5	50	10
PPM 6	50	15

electron microscope at room temperature. The micrographs were recorded at a magnitude of 500 under a voltage of 20 kV.

Degree of Grafting

Following irradiation, the hydrogels were washed thoroughly with doubly distilled water to remove the soluble components such as unreacted monomer, and FAS, and dried at 50°C to constant weight. The degree of grafting was determined [24] gravimetrically using the following equation

$$\text{Grafting}(\%) = \left[\frac{W_g - W_o}{W_g}\right] \times 100 \quad (1)$$

where W_o and W_g are the weights of the hydrogels before and after grafting, respectively.

Swelling Studies

The swelling behavior of the MAA-grafted hydrogels was investigated by carrying out swelling measurements in an aqueous buffer media of pH 1.2, 4.0, 7.0 and 9.0 using standard buffer solutions, and the swelling kinetics and diffusion parameters were evaluated. The swelling studies were made using an electronic balance (Shimadzu AUX 120, Japan) with an accuracy of ± 0.1 mg. Pre-weighed dry hydrogels were immersed in excess of the buffer solution at room temperature. After specific intervals of time, the gels were removed from the medium, the surface-adhered liquid drops were wiped with blotting paper and the increase in weights was measured. The measurements were continued until the weight of the swollen hydrogels attained a constant value. The swelling ratio (S) was calculated [25–26] using

the following expression

$$\text{Swelling (S) (\%)} = \left[\frac{(W_t - W_o)}{W_o}\right] \times 100 \quad (2)$$

where W_o and W_t are the weights of the dry and swollen gels, respectively. The amount of water a swollen gel can hold at equilibrium was expressed as % equilibrium water content (%EWC) which was calculated [26–27] using the following expression

$$\%\ \text{EWC} = \left[\frac{(W_e - W_o)}{W_e}\right] \times 100 \quad (3)$$

where W_e is the weight of the gel at equilibrium. All experiments were performed in triplicate.

Loading of Metoprolol Tartarate

Metoprolol tartarate [28] was selected as a model drug to incorporate in the prepared hydrogels. 50 mg of hydrogel were soaked for 48 h in 5 ml of aqueous solution containing 50 mg of metoprolol tartarate (MT). Later the excess amount of drug solution was drained out and the hydrogels were washed repeatedly with water to remove the adhered drug. These hydrogels were then dried at controlled temperature in vacuum until they attained constant weight. The dried gels were stored in a dessicator and used for further studies like drug-loading and release kinetics.

Estimation of Drug Loading

Loading efficiency of MT in the hydrogels was determined spectrophotometrically. About 50 mg of the drug-loaded hydrogels were placed in 10 ml of water and stirred vigorously for 48 h to extract the drug from the hydrogels. The solution was filtered, diluted suitably and assayed by UV spectrometer (Shimadzu 1601) at a fixed wavelength (λ_{max} of drug) of 274 nm. The % drug loading was calculated [19–20] using the following equation:

$$\%\ \text{drug loading} = \left[\frac{\text{amount of drug in hydrogels}}{\text{amount of hydrogels}}\right] \times 100 \quad (4)$$

In Vitro Release Profile

To obtain information about the possible mode of action of the proposed drug delivery system in the human body, it is often more

convenient to perform the same studies in an environment almost similar to that in the body. Hence, for the purpose of carrying out the drug release study in an *in vitro* manner, two buffer solutions, of pH 1.2 and 7.4, were prepared and the drug release studies were carried out in these media using USP – 1 basket type apparatus (Electrolab TDT-08L Dissolution Tester). 50 mg of drug-loaded hydrogels were taken in the basket and immersed into the dissolution tank containing 500 ml of the buffer. The basket was maintained at 75 rpm at 37°C, 5 ml of the sample was withdrawn at predetermined time intervals and replaced with equal volumes of fresh dissolution medium. These aliquots were diluted suitably with corresponding buffer and the amount of the drug released was estimated. The percentage cumulative drug release (CDR) was calculated [29–31] from the following equation:

$$\%\text{CDR} = \left[\frac{\text{amount of drug released}}{\text{amount of drug loaded}}\right] \times 100 \tag{5}$$

The results obtained are an average of six trials.

RESULTS AND DISCUSSION

Structure and Morphology

Grafting of MAA onto a PVP-PEO network was attempted by electron beam irradiation. A series of experiments was carried out with the objective of obtaining the highest grafting percentage by changing the irradiation dose and MAA concentration. Figure 1 shows the variation of % grafting with both dose and MAA concentration. Percentage grafting increases (68–81%) with an increase in dose (5–15 kGy) and MAA concentration (30–50%). The extent of grafting was found to be influenced by the concentration of the monomer in the solution as well as the total dose employed for grafting. For a particular concentration of MAA, the degree of grafting did not change much with the dose, but the influence of the concentration of MAA on the degree of grafting was appreciably high.

Scanning electron micrographs of PVP-PEO hydrogels showed homogeneous texture, indicating high miscibility between PVP and PEO. The surface morphology appeared to be porous in ungrafted gel, but reduced on grafting with MAA.

FTIR spectra of pure and grafted hydrogels show the characteristic peaks of the constituents PVP, PEO and MAA. The peaks observed at 3525.5 cm^{-1} for PVP-PEO and at 3405 cm^{-1} for PMAA-grafted

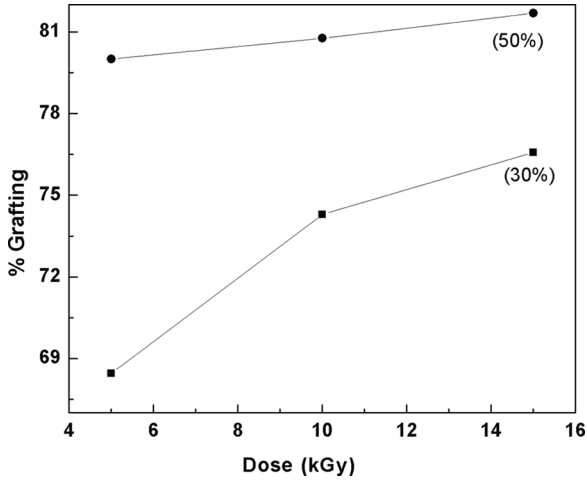


FIGURE 1 % Grafting of PMAA on PVP-PEO hydrogels at various dose.

PVP-PEO are due to O-H stretching of end groups of PEO and carboxylic group of PMAA, respectively. The peak corresponding to C-H stretching is observed at 2895.2 cm^{-1} and 2984 cm^{-1} for ungrafted and grafted gels, respectively. The peak observed at 1668 cm^{-1} for PVP-PEO is due to carbonyl stretching of PVP. In the grafted gel, this peak gets shifted and is observed as a sharp peak at 1719 cm^{-1} . A peak at 1495 cm^{-1} for PVP-PEO and 1483 cm^{-1} for PMAA-grafted PVP-PEO is due to the asymmetric bending of the C-H bond. The C-N stretching of PVP was shifted from 1236 cm^{-1} to 1256 cm^{-1} on grafting. The peak corresponding to C-O-C stretching of PEO is seen at 1150 and 1171 cm^{-1} for ungrafted and grafted gels, respectively.

Swelling Studies

The effect of pH of the medium on the swelling behavior of the gels was studied by maintaining the pH of the swelling medium at 1.2, 4.0, 7.0 and 9.0. The swelling behavior exhibited by the representative hydrogels PPM 1 and PPM 4 is shown in Figure 2. The % **S** value of the hydrogels at various pH follows the order $1.2 < 4 < 7 < 9$. At pH 7 and 9, the amount of water absorbed by the hydrogel was much higher than at pH 1.2 and 4, at the same time point. This is due to the fact that when the pH of the external environment is above the pK_a of poly (methacrylic acid), ionization of the carboxylic acid groups occurs which results in a more hydrophilic polymer network leading to rapid

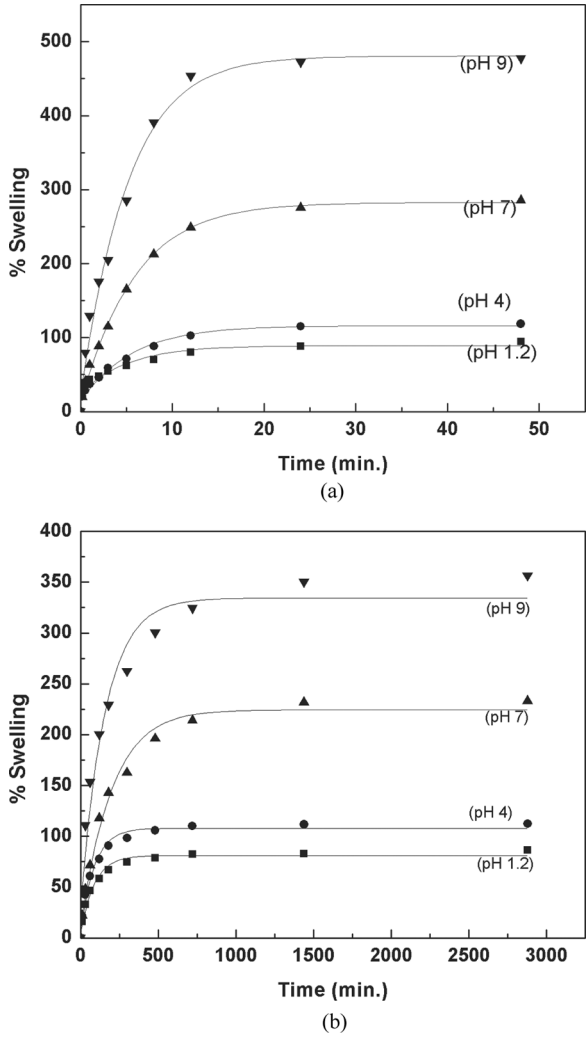


FIGURE 2 The swelling isotherm of the hydrogels (a) PPM 1 and (b) PPM 4.

absorption of water and higher swelling ratio [10]. Increase in the ionization of functional groups at a pH greater than pK_a causes electrostatic repulsion between the ionized groups, leading to chain expansion, which in turn affects chain relaxation. As a result the hydrogels at higher pH swelled by relaxation-controlled mechanism [32–33].

TABLE 2 Equilibrium Swelling Data for Hydrogels at Various pH

Gel Type	Equilibrium swelling (%)			
	pH 1.2	pH 4.0	pH 7.0	pH 9.0
PPM 1	94.4 ± 0.41	118.6 ± 3.0	285.6 ± 3.11	477.4 ± 6.70
PPM 2	93.1 ± 0.95	112.2 ± 4.12	229.9 ± 3.51	397.4 ± 5.57
PPM 3	89.6 ± 0.96	106.3 ± 2.34	225.5 ± 3.95	270.3 ± 7.64
PPM 4	96.4 ± 1.74	112.5 ± 2.99	233.3 ± 3.22	356.5 ± 4.20
PPM 5	92.9 ± 1.83	104.3 ± 3.15	221.5 ± 2.30	339.3 ± 3.52
PPM 6	91.3 ± 0.96	103.7 ± 1.73	218.3 ± 3.61	332.9 ± 5.68

The effect of pH of the medium on the equilibrium swelling of the gels made with varying concentrations of MAA and at different doses is tabulated in Table 2. The results show that on increasing the dose from 5 to 15 kGy, there was a significant fall in the swelling of the hydrogels at all pH values studied. The results further reveal that the gels with higher grafting swell to lesser extent when compared to those with lower MAA content, which could be due to the increase in the compactness of the network with increased level of grafting, which restricts the mobility of chain segments and the extent of swelling.

Kinetics of Swelling

As the matrix consists of hydrophilic polymers with ionizable groups, it is expected that during the swelling process water molecules would interact with the matrix components through ionic, dipolar and hydrogen bonding interactions. The kinetic analysis of swelling process was made [25–26] using the following equation:

$$\frac{dS}{dt} = k_s(S_{eq} - S)^2 \tag{6}$$

where, S_{eq} and k_s denote the degree of swelling at equilibrium and swelling rate constant, respectively. The integration of the above equation over the limits, $S = S_0$ at time $t = t_0$ and $S = S$ at time 't', gives the following equation:

$$\frac{t}{S} = A + Bt \tag{7}$$

where B is the inverse of the maximum or equilibrium swelling ($B = 1/S_{eq}$), $A = (1/k_s\, S_{eq})$ is the reciprocal of the initial swelling rate (R_i) of the hydrogel, and k_s is the swelling rate constant. The plots of t/S versus t are shown in Figure 3. The linearity of the plots indicates that the swelling process follows second order kinetics. The

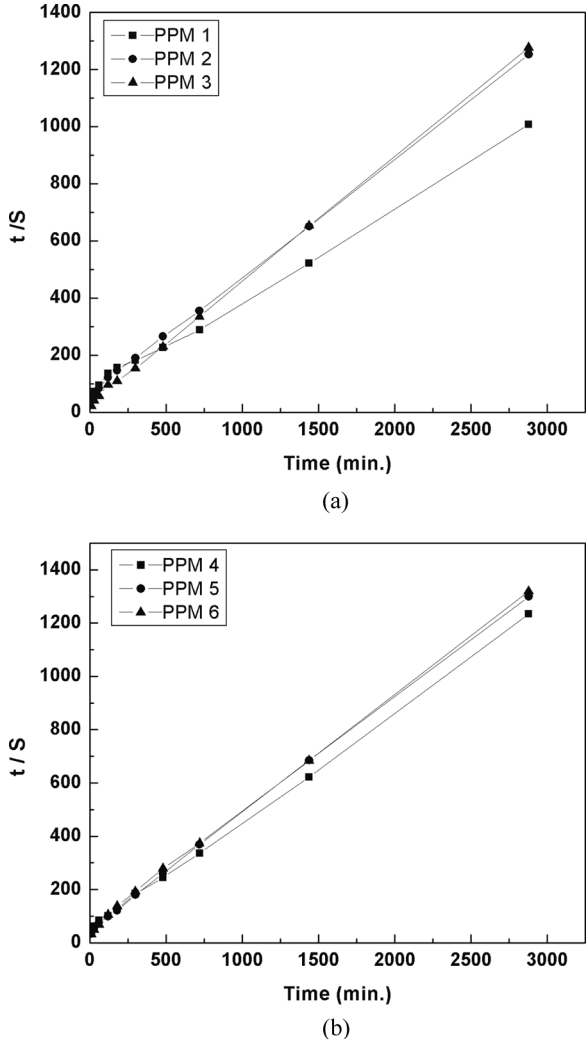


FIGURE 3 Swelling rate curves of hydrogels (a) PPM 1–3 and 4–6.

initial rate of swelling (R_i) and the swelling rate constant (k_s) for the hydrogels were calculated from the intercept of the respective curves on the ordinate axis and theoretical equilibrium swelling (S_{eq}) from the corresponding slopes. The values of these parameters obtained for the gels are presented in Table 3. From the table, it is confirmed that the maximum equilibrium swelling ratio values calculated theoretically from B values are in good agreement with equilibrium

TABLE 3 Swelling Parameters of Grafted Hydrogels at pH 7

Formulation code	PPM 1	PPM 2	PPM 3	PPM 4	PPM 5	PPM 6
Equilibrium swelling, S%	286	230	225	233	222	218
Equilibrium water content, EWC%	74.06	69.68	69.28	69.99	68.90	68.58
The initial swelling rate Ri	0.95	1.15	2.48	1.38	1.51	1.42
Swelling rate constant $ks \times 10^{-1}$	1.01	2.01	4.7	2.3	2.9	2.8
Maximum equilibrium swelling S_{max} %	306	239	230	243	227	224
Swelling exponent n	0.61	0.59	0.42	0.65	0.58	0.50
Swelling constant K	0.50	0.40	0.02	0.32	0.22	0.21
Diffusion coefficient of water $D \times 10^{-5}\,cm^2\,min^{-1}$	1.45	1.92	2.83	2.64	2.97	2.36

swelling ratio values determined experimentally. The initial swelling rate and swelling rate constant values are observed to be dependent on the gel preparation conditions.

To evaluate the diffusion phenomena of water into the gels, the initial 60% of the swelling data was fit into the following equation [25,26]:

$$F = \left[\frac{(W_t - W_o)}{W_o}\right] = Kt^n \tag{8}$$

where F denotes the swelling power of the gel, defined as the amount of water contained in a gel/unit weight of the material; K is the swelling constant characteristic of the polymer network and n, is the swelling exponent which characterizes the mechanism of diffusion of water into the network. The ln F vs. ln t plots for the various gels studied here are shown in Figure 4. The values of n and K were calculated from the slopes and intercepts of the lines and are listed in Table 3. The n values for hydrogels made at lower dose were in the range of 0.58–0.65, indicating that the water transport mechanism in these gels was anomalous (relaxation-controlled) diffusion, whereas the gels made at 15 kGy were characterized by the n value in the range 0.42–0.5, indicating Fickian diffusion.

The diffusion coefficients for the gels were calculated [25,26] using the equation:

$$\frac{W_t}{W_\infty} = \frac{4}{r}\left[\frac{Dt}{\pi}\right]^{1/2} \tag{9}$$

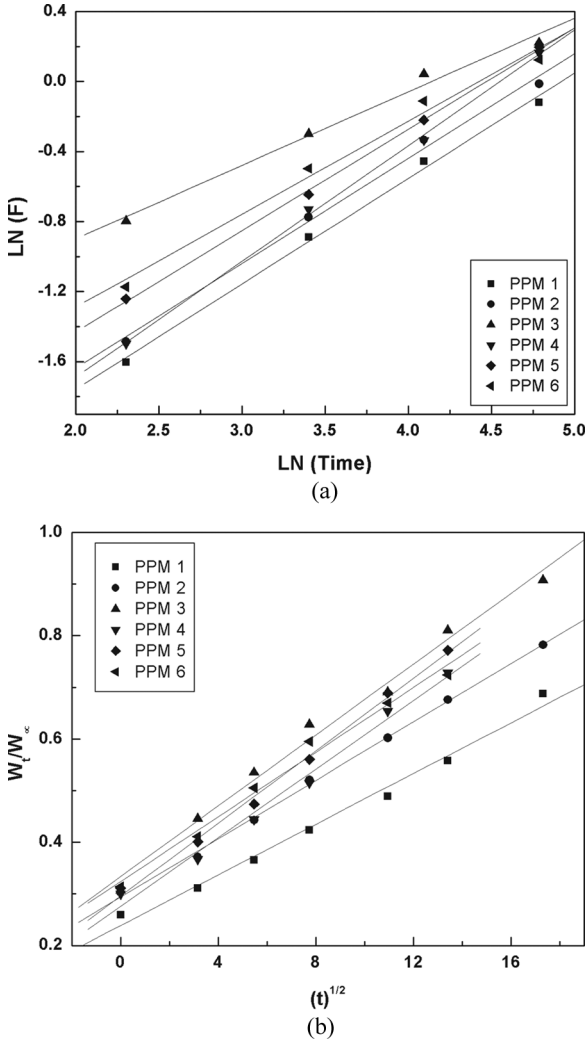


FIGURE 4 (a) Swelling kinetic curves and (b) Diffusion curves of PMAA-grafted hydrogels.

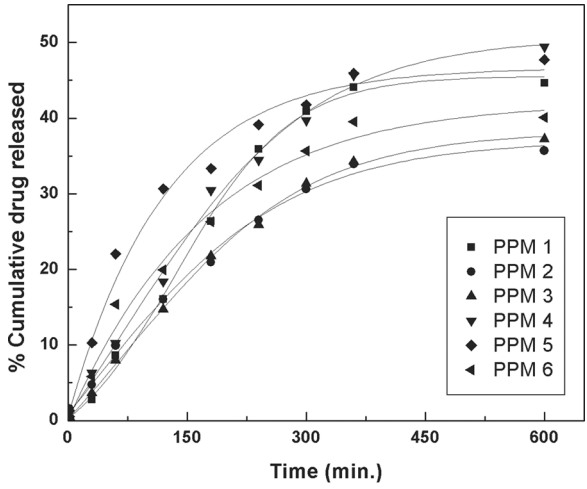
where D and r indicate the water diffusion coefficient and radius of the gels, respectively. The values of diffusion coefficient were obtained from the plots of W_t/W_∞ vs. $t^{1/2}$ for the initial 60% of the data as displayed in Figure 4 and are listed in Table 3. The D value increases with an increase in the concentration of MAA in the gel at low dose

rates. But it is observed to decrease from 2.83×10^{-5} to 2.36×10^{-5} for gels made at 15 kGy.

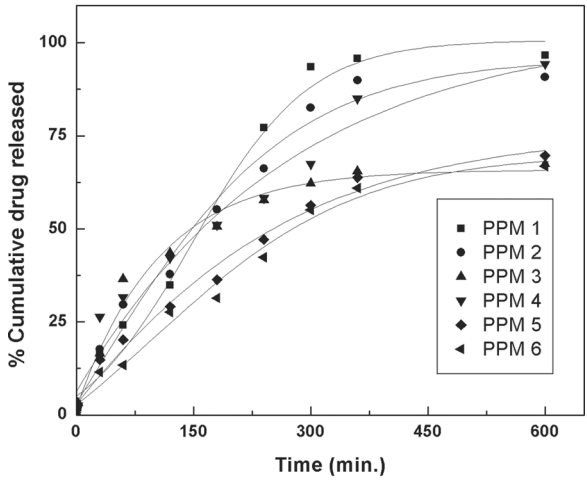
Release of Metoprolol Tartarate from Grafted Hydrogels

When the drug-loaded dry gels come in contact with a solvent, relaxation of the polymer chains takes place and the gel swells. The entrapped drug passes into the external receiving medium, crossing the swollen polymeric matrix. Depending on the rate of the swelling process, the drug release may be Fickian or non-Fickian [1-3]. In the present work, the release of metoprolol tartarate from the hydrogels was studied at pH 1.2 and 7.4 at the physiological temperature of 37°C. The results depicted in Figure 5 clearly indicate that the drug-loaded sample releases a higher amount of MT in the medium of pH 7.4, and a comparatively low amount of the drug is found to be released at pH 1.2. The quantity of the total drug released from the hydrogels in the release medium of pH 1.2 and 7.4 are in the range 35.7–49.4% and 66.8–96.7%, respectively. The $t^{1/2}$ values (time required for the release of 50% of the total drug loaded) for the sample in the medium of pH 7.4 is found to be ≈180 min for PPM 1–4 and ≈280 min for PPM 5–6. At pH 1.2, the total release was less than 50 % for all formulations. The results indicate that the release of the drug from these gels depends on swelling.

An important parameter which influences the release profile of the loaded drug is the extent of loading. In the present case it is observed that the extent of loading decreases with an increase in irradition dose or grafting, and the decrease is negligibly small. Figure 5 indicates that the % CDR also decreases with an increase in dose. This may be due to the increase in the compactness of the network which restricts the mobility of chain segments and also the diffusion of the drug from the medium into the gels, and vise versa. Further, the fraction of metoprolol tartarate released at pH 7.4 was lower for gels PPM 4–6 when compared to PPM 1–3. On the other hand, at pH 1.2 the gels PPM 4–6 showed higher values of MT release compared to PPM 1–3. This observation correlates with the diffusion behavior of these gels. The release data were analyzed using an exponential relation, $W_t/W_\infty = kt^n$ for $0 \leq W_t/W_\infty \leq 0.6$, where 'n' is diffusional exponent. The diffusion coefficient calculated for PPM 1–3 hydrogels were higher at pH 7.4 (3.49×10^{-5} to $7.48 \times 10^{-5}\,cm^2\,min^{-1}$) and lower at pH 1.2 ($4.29 \times 10^{-5} - 4.59 \times 10^{-5}\,cm^2\,min^{-1}$), whereas the diffusion coefficient values for PPM 4–6 hydrogels were observed to be higher at pH 1.2 (4.42×10^{-5} to $7.18 \times 10^{-5}\,cm^2\,min^{-1}$) and lower at pH 7.4 ($2.81 \times 10^{-5} - 4.12 \times 10^{-5}\,cm^2\,min^{-1}$). This indicates that the drug release from these gels was diffusion-controlled.



(a)



(b)

FIGURE 5 % CDR from PMAA-grafted hydrogels (a) at pH 1.2 and (b) at pH 7.4.

Release Kinetics of MT from Grafted Hydrogels

In order to describe the kinetics of the release process of a drug in all formulations, the kinetic data are fit into various equations. The zero-order rate equation describes the systems where the release rate is independent of the concentration of the drug. The first-order equation

TABLE 4 Some Drug Release Parameters at pH 1.2

Gel type	Correlation coefficient (r^2) value				(n) value Korsemeyer	Diffusion coefficient, D ($cm^2\ min^{-1}$)
	Zero order	First order	Higuchi's square root	Korsemeyer		
PPM 1	0.91	0.93	0.96	0.99	1.08	4.29×10^{-5}
PPM 2	0.92	0.94	0.98	0.98	0.58	4.59×10^{-5}
PPM 3	0.93	0.95	0.98	0.99	0.83	4.38×10^{-5}
PPM 4	0.94	0.96	0.98	0.99	0.72	4.42×10^{-5}
PPM 5	0.87	0.90	0.97	0.99	0.97	7.18×10^{-5}
PPM 6	0.90	0.92	0.98	0.99	0.98	6.21×10^{-5}

describes the release from systems where release rate is dependent on the concentration of the drug. The Higuchi square root equation [34] describes the release from systems where the solid drug is dispersed in an insoluble matrix, and the rate of drug release is related to the rate of drug diffusion [34,36]. The equation that best fits the release data is selected based on the correlation coefficient (r^2) value of fit. The r^2 values obtained for the various fits made with the present data are given in Tables 4 and 5. When the dissolution data obtained at pH 1.2 and 7.4 for all formulations were plotted in accordance with the zero-order equation, the plots are curvilinear, suggesting that the release process is not zero-order in nature. When the dissolution data were plotted in accordance with the first-order equation, that is the log (% drug remained) vs. time, a linear relationship was obtained with high r^2 values than for zero-order fit indicating that the release is an apparent first-order process. This indicates that the amount of drug

TABLE 5 Some Drug Release Parameters at pH 7.4

Gel type	Correlation coefficient (r^2) value				(n) value Korsemeyer	Diffusion coefficient, D ($cm^2\ min^{-1}$)
	Zero order	First order	Higuchi's square root	Korsemeyer		
PPM 1	0.91	0.94	0.96	0.99	0.72	3.49×10^{-5}
PPM 2	0.91	0.96	0.98	0.99	0.74	4.76×10^{-5}
PPM 3	0.85	0.90	0.96	0.99	0.65	7.48×10^{-5}
PPM 4	0.94	0.98	0.99	0.98	0.67	4.12×10^{-5}
PPM 5	0.94	0.97	0.99	0.99	0.59	2.81×10^{-5}
PPM 6	0.95	0.97	0.98	0.99	0.55	3.10×10^{-5}

released is dependent on the matrix drug load. To evaluate the drug-release mechanism from the gels, plots of percent drug released vs. $t^{1/2}$, as per Higuchi's equation were constructed. These plots were found to be linear for all the formulations with correlation coefficient values in the range 0.96–0.98 for pH 1.2 and 0.96–0.99 for pH 7.4 indicating that the drug release from the matrix was diffusion-controlled. When the release data were analyzed as per Korsemeyer and Peppas's equation [37], the release exponent 'n' was >0.5 for all the formulations, indicating an anomalous diffusion as the release mechanism.

CONCLUSION

The extent of grafting of MAA on the PVP-PEO network system can be optimized by the proper selection of preparation conditions, namely, the concentration of monomer and the irradiation dose. The grafted gels show a pH and composition-dependent swelling behavior. The swelling is observed to occur by relaxation of chains segments in the network structure, controlled by the extent of grafting and dissociation of MAA groups. Further, the extent of loading and release of MT from the grafted gels is observed to be influenced by the network composition. The release pattern of MT is found to be first order with all formulations. When the release data were analyzed as per Korsemeyer and Peppas's equation, the release exponent 'n' was >0.5 for all the formulations, indicating an anomalous diffusion as the release mechanism. From the present study, it may be inferred that these gels may prove promising matrix materials for sustained-release formulations of drugs such as MT for gastrointestinal delivery.

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