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Short Communication

SYNTHESIS, CHARACTERIZATION AND SWELLING BEHAVIOR STUDIES OF GUAR GUM-GRAFTED-ACRYLAMIDE-CO-HYDROXYETHYL METHACRYLATE HYDROGEL

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ABSTRACT

A novel high water absorbent and environment friendly guar gum-grafted-acrylamide-co-hydroxyethyl methacrylate (GG-AAM-co-HEMA) hybrid hydrogel was synthesized through free radical copolymerization method using ammonium persulphate, *N,N*'-methylenebisacrylamide and glutaraldehyde as initiator and cross-linking agents respectively in distilled water solvent medium. The structural and morphological characterization of synthesized hydrogel was carried out using FT-IR, and SEM techniques respectively. The water absorption capacity test was also conducted for the obtained hydrogel. The FT-IR data confirmed the incorporation of hydroxyethyl methacrylate and acrylamide in the gaur gum polymeric chain while SEM confirmed the formation of uniform porous structure in the hydrogel. The high water swelling capacity up to 75% confirmed the highly water-absorbent nature of the hydrogel which makes it useful for soil conditioning and nourishing applications in agriculture.

Keywords: Guar Gum, Swelling, Copolymerization, Acrylamide, Agriculture

1. INTRODUCTION

In 1960, Wichterle and Lim [1] synthesized the first artificial crosslinked hydrogel using poly-2-hydroxyethylmethacrylate (pHEMA) for human tissues related applications. Since then hydrogels have become materials of great importance for human society. Hydrogels are class of polymers which have the tendency to uphold significant amount of water in their three-dimensional network crosslinked structure without undergoing any kind of auxiliary disfigurement [2-4] because of the presence of functional groups such as -OH, -CONH, -COOH, -$CONH_2$and –SO_3H etc, which provides hydrophilic nature to the hydrogel along with the crosslinking which strengthen and stabilizes the polymeric matrix of the hydrogel [5-7]. Hydrogels showed properties like non-toxicity, high water retention, high water absorption, high porosity and flexibility [8, 9] due to their hybrid networked structure [10].

At present times also, studies related to hydrogels are still of high significance because of their versatile nature and applications in a wide range of applications such as controlled drug delivery, wastewater treatment, soil nourishment, and conditioning, cosmetics manufacturing, textiles, tissue engineering, bio-sensors, etc [11-13] and there are still a lot of areas to investigate.

Guar gum is an eco-friendly polysaccharide and provides excellent binding stability due to its thixotropic behavior as well as its ability to form H-bonding which makes it widely useful for a wide range of applications whether in the field of agriculture, bio-medical, etc. but it lacks environmental stability due to poor microbial resistance which reduces their shelf life [14,15]. Acrylamide based synthetic hydrogels experienced a major transition in volume during swelling but cannot uphold it for a longer period of time because of the lack of hydrolytic stability similarly porous structure of poly-2-hydroxyethylmethacrylate (pHEMA) can permit the high amount of water inside hydrogel matrix but it has low degradation rate [16-18].

In our research work, we have synthesized a hybrid hydrogel by free-radical copolymerization of guar gum, acrylamide and hydroxyethyl methacrylate which results in a hydrogel which has high water absorption properties along with good environmental as well as hydrolytic stability and can be used for applications related to soil conditioning and soil nourishment, etc.

2. EXPERIMENTAL

2.1. Material

Chemical reagents that were utilized throughout the research period are of analytical reagent (AR) grade and used without any purification method or chemical treatment. Acrylamide, guar gum, glutaraldehyde, and ammonium persulphate was acquired from Thomas Baker (Chemicals) Pvt. Ltd., while hydroxyethylmethacrylate was obtained from S-D Fine Chemical Ltd. and *N,N'*-methylenebisacrylamide was procured from Sisco Research Laboratories Pvt. Ltd.

2.2. Synthetic Method

In a 50 mL beaker, 15 mL distilled water was taken and then 2.5 gm acrylamide was added to it at room temperature. In another 50 mL beaker, 15 mL hot distilled water was taken in which 0.075 g guar gum was added with continuous stirring rate. Then contents of both the beakers were transferred into the third 250 mL beaker which was placed inside the water bath above a magnetic cum hot plate stirrer. Ten mL of hydroxyethylmethacrylate was poured into the third beaker with constant stirring and temperature between 65-70°C until all the components mix properly. Then 0.6 gm ammonium persulphate (initiator) and 0.10 gm *N,N'*-methylenebisacrylamide and 2.5 mL glutaraldehyde (cross-linking agents) were added to the above mixture until a viscous solution was obtained, which was then transferred into the Petri dish and dried in an air oven at 80-85°C up to 24 hr. The synthesis process diagram for the same was depicted in fig. 1.

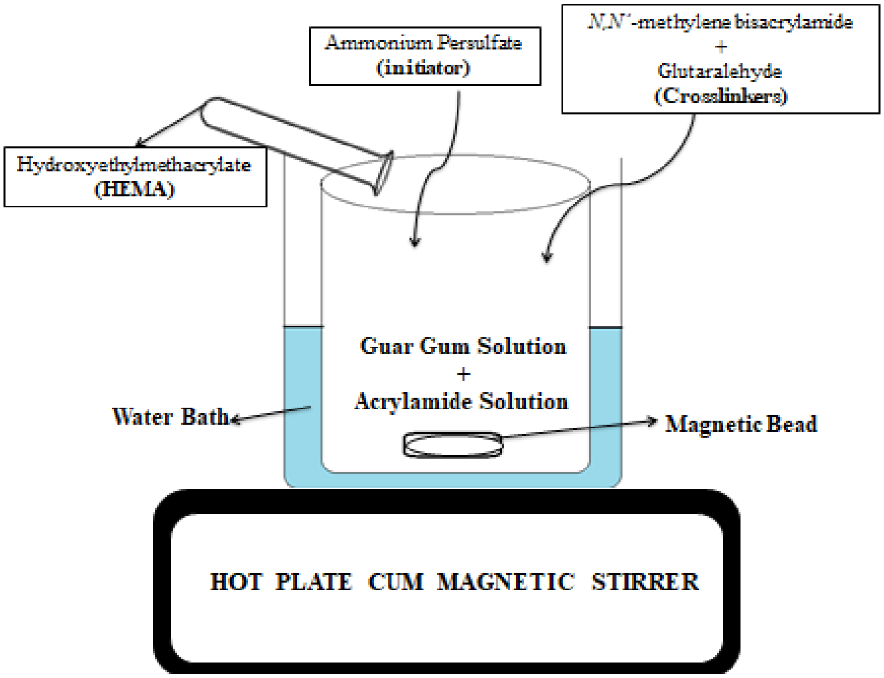

Fig.1: Synthetic process of GG-AAM-co-HEMA hydrogel

3. RESULTS AND DISCUSSION

In the present research work, we have synthesized a novel guar gum-acrylamide-co-hydroxyethyl methacrylate (GG-AAM-co-HEMA) based hydrogel. The structure and morphology of newly synthesized hydrogel were confirmed using FT-IR and SEM analysis techniques while its water swelling behavior was investigated using swelling test [19] from the formula given below:

$$\mathrm{SW}\,(\%) = \frac{M_t - M_o}{M_o} \times 100$$

Here, M_o = Dry weight of the hydrogel

M_t = Wet weight of the hydrogel

3.1. FT-IT Analysis:

The FTIR spectrum for GG-AAM-co-HEMA hydrogel was illustrated in fig. 2. A peak around 3747.06 cm^{-1} was observed for –OH stretching in guar gum. A single peak at 3184.41 cm^{-1} was observed for 2° amide –NH stretching vibrations. Similarly, peak at 2933.17 cm^{-1} and 1647.89 cm^{-1} were assigned for -CH$_2$ stretching and -C=O stretching for amide group respectively. The peak at 1357.07 cm^{-1} was observed for O-H bending in alcohol while peaks at 1174.37 cm^{-1} and 1083.45 cm^{-1} were assigned for-C-O stretching in ester and in 1^{o}alcohol respectively. Similarly, peaks around 968.48 cm^{-1}and 721.25 were observed for 1,4 and 1,6 glycosidic linkages respectively.

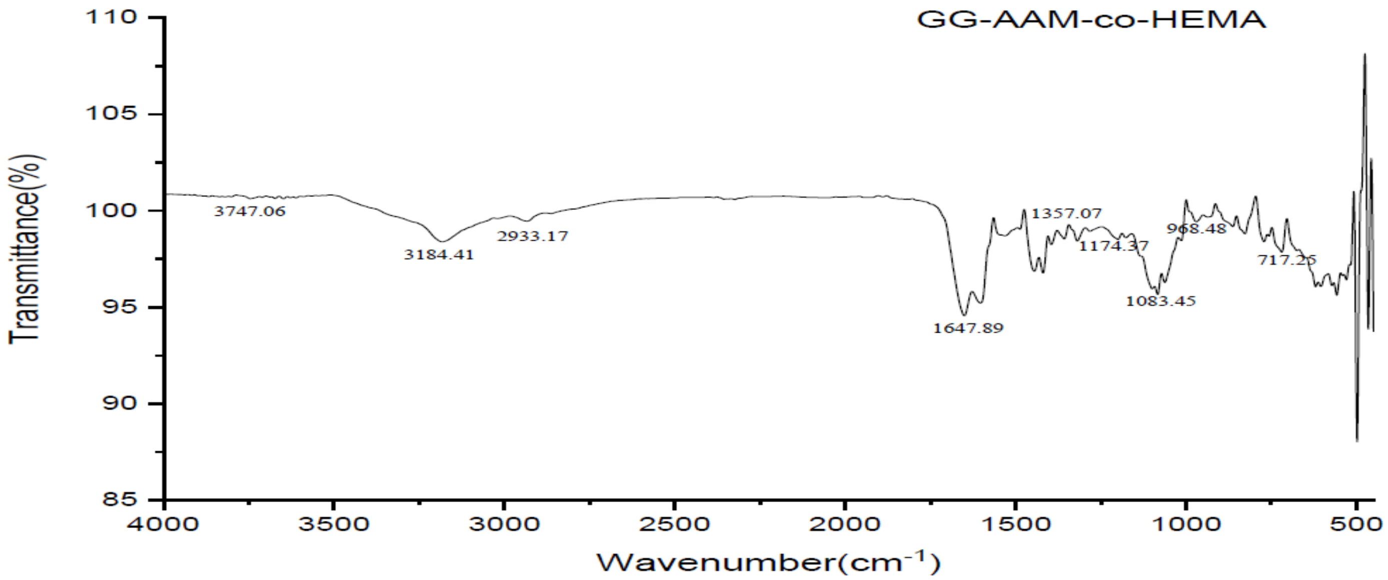

Fig. 2: FT-IR Spectra for GG-AAM-co-HEMA based hydrogel

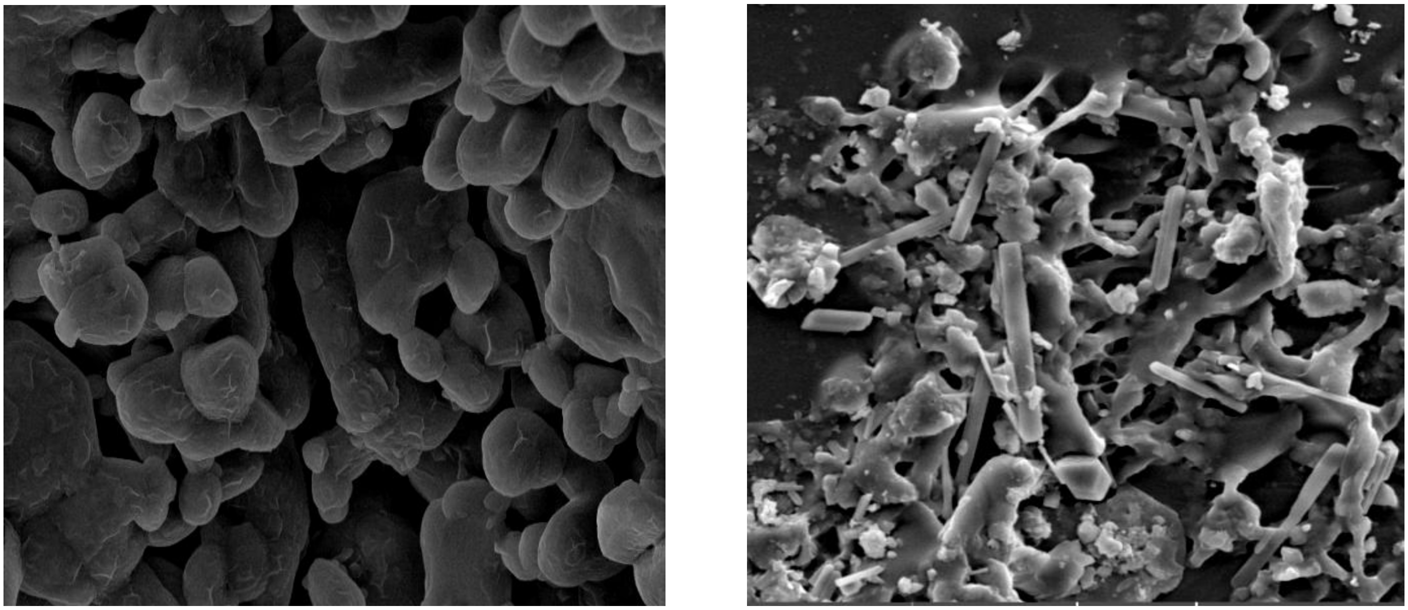
(a) (b)

Fig.3: SEM image for GG-AAM-co-HEMAbased hydrogel at (a) 5,000 nm and (b) 10,000 nm range

3.2.SEM Analysis

The surface morphology images of the GG-AAM-co-HEMA based hydrogel were carried out using SEM analysis, which was illustrated in fig.3 at around 5000 and 10,000 nm magnification ranges respectively. SEM photographs showed the presence of smooth surface morphology along with porous structure [Fig. 3(a)] throughout the hydrogel, while in [Fig. 3(b)] it was observed that HEMA has been thoroughly distributed in the hydrogel matrix in an uneven manner without forming any agglomerates.

3.3. Swelling Test

The swelling behavior of GG-AAM and GG-AAM-co-HEMA based hydrogels were studied in distilled water at 37ºC until equilibrium was attained by both the hydrogels, and it was observed that GG-AAM based hydrogel showed 42.3% swelling while GG-AAM-co-HEMA based hydrogel showed swelling of 74.8%. The comparative graph of swelling capacities of GG-AAM and GG-AAM-co-HEMA based hydrogels was depicted in fig. 4. The increase in the swelling was due to the presence of acrylate groups in HEMA which on grafting with GG-

AAM matrix forms –COO negative ions, because of which electrostatic repulsion takes place and this increases the total space inside polymer chains and it finally results in an increased swelling capacity of the hydrogel [20, 21].

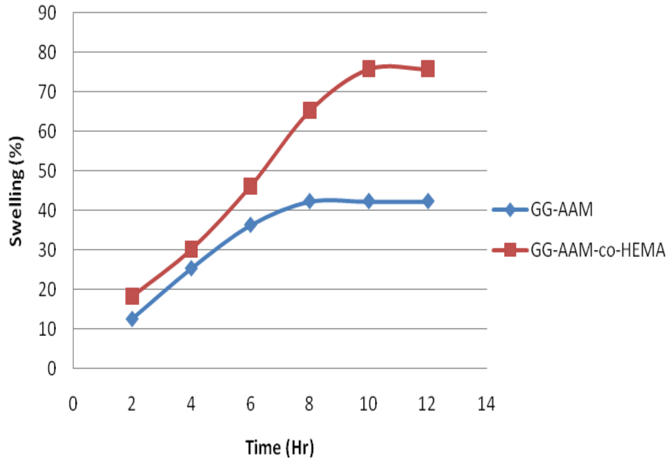

Fig. 4: Swelling behavior of GG-AAM and GG-AAM-co-HEMA hydrogels

4. CONCLUSION

During our research work, we have synthesized a novel GG-AAM-co-HEMA based hydrogel which has shown good hydrolytic stability as well as good water absorption capacity up to 75%. The final synthesized hydrogel can be proposed to use as a conditioning and nourishing agent for various agricultural applications.

5. ACKNOWLEDGMENT

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