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ORIGINAL PAPER

Novel organic–inorganic composite material as a cation exchanger from a triterpenoidal system of dammar gum: synthesis, characterization and application

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Abstract A pioneer study has been conducted to synthesize novel hydrogel starting from a non-cellulosic raw material, gum dammar-a triterpenoidal system, and then converting this hydrogel into an organic–inorganic composite zirconium-based ion exchanger. Gum dammar was cross-linked with polyacrylamide zirconium (IV) iodo-oxalate [Gd-cl-poly(AAm)-Zr (IV) iodo-oxalate] by incorporating inorganic precipitates into the polymeric mixture. The polymeric mixture was synthesized using gum dammar (Gd), acrylamide (AAm), *N*, *N*′-methylene-bis-acrylamide (MBA) and potassium persulphate (KPS). The reaction conditions for synthesis of hydrogel and ion exchanger such as time (120 min), temperature (70 °C), solvent (4 mL), concentration of monomer (12.97×10^{-3} mol/L), initiator (1.48×10^{-4} mol/L), cross-linker (4.22×10^{-4} mol/L) and ratio of zirconium oxychloride (0.1 M), potassium iodate (0.1 M) and oxalic acid (0.1 M) in ratio 2:3:2 were optimized to obtain maximum ion exchange capacity (2.02 meq/g). The morphology and structure of hydrogel and ion exchanger were studied using FTIR, SEM, XRD and TGA/DTA/DTG. The SEM study was followed by energy dispersive spectroscopy for elemental analysis. The ion exchanger was quite stable in various acids and bases at low concentration but it completely dissolved in acids and bases at high concentrations. Distribution studies showed that the synthesized ion exchanger had high selectivity for Pb^{2+} ions. Thus, the polymeric-inorganic hybrid material showed integration of both inorganic and organic characteristics within the composite material.

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Keywords Gum dammar · Hydrogel · Copolymerization · Ion exchanger · Distribution studies

Introduction

Hydrogels are cross-linked three-dimensional polymeric networks containing hydrophilic groups which do not dissolve in water at physiological temperature or pH, but they can absorb an enormous amount of water or biological fluids compared to their dry weight [1–3]. It has been reported that the swelling capacity of hydrogels is enhanced in presence of hydrophilic groups, high polymer chain flexibility, and the availability of large free volume between polymeric chains. Due to their response to changing environmental conditions such as temperature, pH and solvent composition, scientists have shown their keen interest towards these polymeric networks [4–6]. They have widely been used in many fields such as hygienic products (diapers) horticulture, water blocking tapes, especially in medical (drug delivery and tissue engineering) and mechanical engineering [7, 8]. Recently, much work has been done using these superabsorbents as water managing materials so as to provide sufficient water in deserts [9] and those containing fertilizers such as N, P, K and humic substances [10]. The results proved that the superabsorbent could enhance the water-holding capacity of the soil and was endowed with slow-release fertilizer properties [11].

Various natural polymers like starch, chitosan, dextrin, psyllium, guar gum and gum arabic have been modified by different researchers for their different applications [12, 13]. Many attempts have been made to develop new hydrogels of various natural polymers like gum xanthan, gum ghatti, gum arabic, gum acacia, etc., through various methods such as irradiation and chemically crosslinking [14,