Summary of the Report

On the

Minor Research Project

Entitled

STUDIES IN THE SYNTHESIS OF SUPERABSORBANT POLYMERS

Sponsored by

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Introduction

Superabsorbent polymer (SAP) materials are organic materials with enormous capability of water absorption as high as 1,000-100,000% (10-1000 g/g) Commercial SAP hydrogels are generally sugar-like hygroscopic materials with white-light yellow colour. The SAP particle shape (granule, fibre, film, etc.) has to be basically preserved after water absorption and swelling, i.e., the swollen gel strength should be high enough to prevent a loosening, mushy, or slimy state, being a major practical feature that discriminates SAPs from other hydrogels

Applications

The applications of hydrogels are grown extensively. They are currently used as scaffolds in tissue engineering where they may contain human cells in order to repair tissue. Environmental sensitive hydrogels have the ability to sense environmental stimuli, such as changes of pH, temperature, or the concentration of metabolite and then release their load as a result of such a change. Hydrogels that are responsive to specific molecules, such as glucose or antigens can be used as biosensors as well as in drug delivery systems (DDS). These kinds of hydrogels are also used as controlled-release delivery devices for bio-active agents and agrochemicals. Contact lenses are also based on hydrogels.

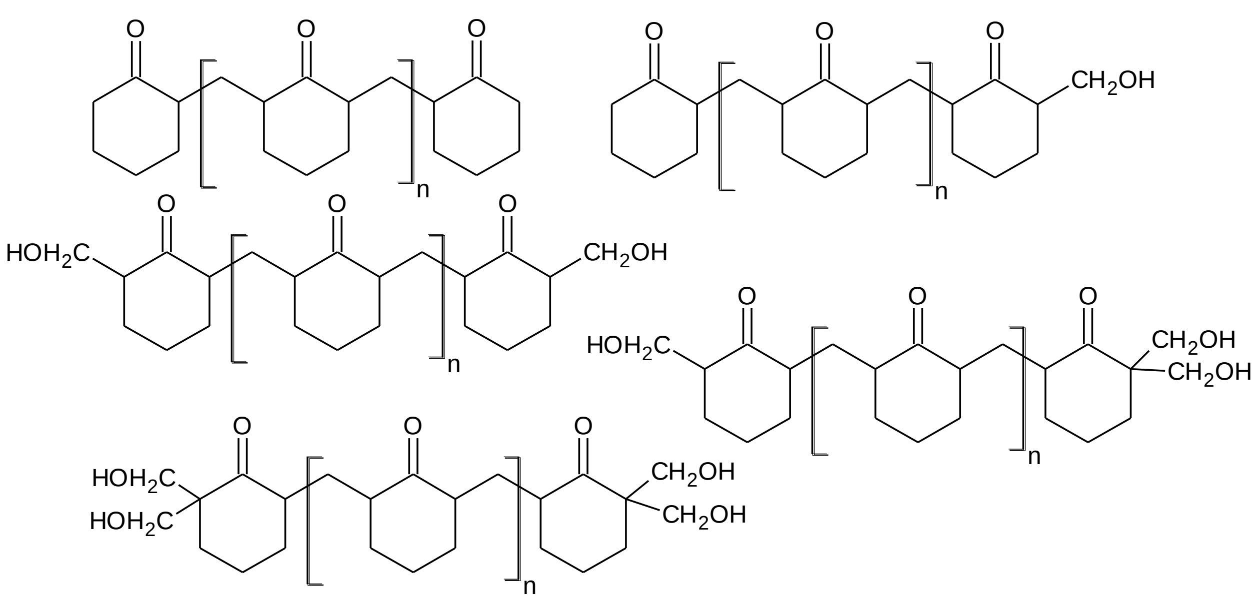
Special hydrogels as superabsorbent materials are widely employed in hygienic uses particularly disposable diapers and female napkins where they can capture secreted fluids, e.g., urine, blood, etc. Agricultural grade of such hydrogels are used as granules for holding soil moisture in arid areas.

Design of new superabsorbent polymers

An ideal super absorbent should have one or a combination of the following aspects. a) It should have enough hydrophilic groups which can get hydrated by electrostatic force of attraction. b) Sites for possible hydrogen bonding to occur should be present. c) There should be an optimum distance between the interacting polymer chains so that the water molecules can get entrapped into the void spaces between the polymer chains intercalating them. d) The synthetic polymer should be readily available or it could be easily synthesized from cheap monomers.

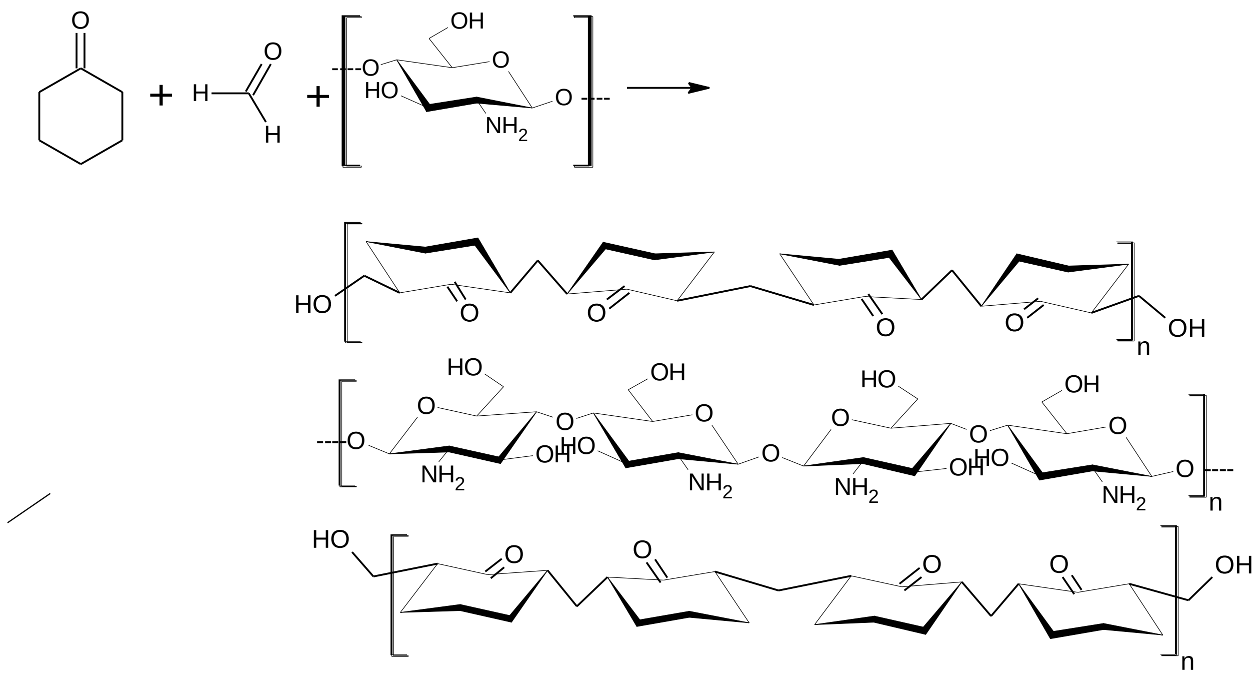
The search for such a polymer led us to choose ketonic (cyclohexanone-formaldehyde) resin for the purpose. The primary OH groups at the two terminals of the chain and the CO groups on each of the monomer unit can facilitate the easy formation of H-bonds between the polymer chains of the ketonic resin and chitosan

Structural features of the different monomer units of ketonic resin.



The ketonic resin, used as a common additive in surface coatings, printing inks and as fillers in ballpoint inks, is available as light yellowish beads. Thus it was also desired that the grafted polymer be obtained as beads to be user-friendly in personal hygiene products. In conventional thermally-initiated emulsion polymerization, the particle size can range from 50 to 500 nm. However, for many novel applications, smaller particle size and monodispersity result in better performance.

We felt it worthwhile attempting a general technique of emulsion polymerization using sodium lauryl sulfate as surfactant and Mohr's salt as redox initiator. Once a method for the formation of polymeric beads could be generated, the same procedure can be employed for the formation of graft polymer of chitosan and ketonic resin as depicted in fig.



Synthesis of the designed polymer.

The polymerization process was carried out by varying the different reaction parameters with the prime aim of preventing the agglomeration of the polymer into a hard lump and isolation in a grit-like form. This form is more acceptable in the market owing to less packing volume as well as the easy handling and environmental considerations. The parameters considered for the process variations were 1) concentration of formaldehyde 2) strength of the base 3) amount of emulsifying agent 4) amount of the redox initiator 5) use of an in situ bleaching or a whitening agent. Each of these parameters were optimized conducting sets of eight to twelve experiments with the aim of yield maximization and getting the white granular material. The weight ratio of the ketone to formaldehyde to sodium hydroxide of 1:1.3:1.8 was noticed to be of an optimum value. The weight ratio of the other three components was 1:0.2:0.035 in order to provide a good result. The weight ratio of the major reactants to that of the minor components was of the order of 50:1. The key observations in these experiments were the very critical role of the redox initiator as well as the whitening agents in imparting the grit-like nature to the polymer. We could not find any precedence in the literature to the use of a combination of a redox initiator and a whitening agent in such polymerization reactions.

Chitosan-cyclohexanone- formaldehyde polymer composite, the designed superabsorbent polymer, was synthesized through grafting of chitosan to an *in situ* generated ketonic resin. Swelling capacity of the hydrogel was found to be in the order of 80 times the weight of the polymer.