

SYNTHESIS AND CHARACTERIZATION OF POLYACRYLAMIDE BASED
HYDROGEL CONTAINING MAGNESIUM OXIDE NANOPARTICLES FOR
ANTIBACTERIAL APPLICATIONS

SEYED ALI ASGHARZADEH AHMADI

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TO MY LOVING FATHER AND MOTHER

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ABSTRACT

A new hydrogel was synthesized based on polyacrylamide and sodium carboxymethylcellulose. N,N'-Methylenebisacrylamide (MBA) was used as cross-linker and ammonium persulfate (APS) and N,N,N',N'-tetra-methylethylenediamine (TEMED) were utilized as initiators. Moreover, The MgO nanoparticles were added to the hydrogel network in order to investigate the antibacterial activity of synthesized polymer. Characterizations of hydrogels were carried out using Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (XRD) and Field Emission Scanning Electron Microscope (FESEM). The physical and chemical characterizations of the prepared hydrogels give valuable information on the morphological structure of polymer, swelling behavior, bonding formation of gels and physical properties. It can be concluded that by incorporation of NaCMC the hydrogel properties are retained chemically and the physical properties are clearly being enhanced in the aspects of swelling capacity, strength and flexibility. This study also investigates the antibacterial activities of prepared hydrogels against *Escherichia coli* which is a Gram negative food pathogenic bacteria. For this purpose, agar diffusion test or agar plate test was carried out and inhibition area for each hydrogel was determined. The inhibition zone for acrylamide hydrogel with NaCMC was about 4.52 cm² since this area for MgO nanocomposite containing 0.03 gram of MgO was 15.19 cm².

ABSTRAK

Hidrogel telah disintesis dari polyacrylamide dan carboxymethylcellulose natrium. N, N'-Methylenebisacrylamide (MBA) yang digunakan sebagai cross-linker dan ammonium persulfate (APS) serta N,N,N',N'-tetra-methylethylenediamine (TEMED) digunakan sebagai ‘initiators’. Selain itu, nanopartikel MgO telah ditambah kepada hidrogel network untuk mengkaji aktiviti antibakteria polimer yang disintesis. Pencirian Hidrogel telah dijalankan menggunakan ‘Fourier Transform Infrared Spectroscopy’ (FTIR), ‘X-ray diffraction’ (XRD) dan ‘Field Emission Scanning Electron Microscope’ (FESEM). Ciri-ciri fizikal dan kimia dalam penyediaan Hidrogel memberikan maklumat mengenai struktur morfologi polimer, tingkah laku ‘swelling’, pembentukan ikatan gel dan sifat-sifat fizikal. Kesimpulanya, penubuhan sifat hidrogel NaCMC jelas mengekalkan sifat kimia dan fizikal yang dipertingkatkan dalam aspek ‘swelling’ kapasiti, kekuatan dan fleksibiliti. Kajian ini juga mengkaji aktiviti antibakteria dalam penyediaan Hidrogel terhadap Escherichia coli yang merupakan ‘Gram negative food pathogenic bacteri’. Tujuan ujikaji ini, adalah ujian resapan agar atau ujian plat agar yang telah dijalankan dan perencatan bagi setiap hidrogel telah jelas ditentukan zon pembentukan bagi MgO nanocomposite yang jelas diperhatikan. Zon perencatan bagi hidrogel akrilamida dengan NaCMC adalah kira-kira $4,52\text{ cm}^2$ sejak kawasan ini bagi MgO Komposit nano mengandungi 0.03 gram MgO adalah $15,19\text{ cm}^2$.

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LIST OF ABBREVIATIONS

AAm	Acrylamide
AM	Antimicrobial
APS	Ammonium persulfate
FTIR	Fourier Transform Infrared Spectroscope
FESEM	Field Emission Scanning Electron Microscope
MBA	N,N'-Methylenebisacrylamide
MgO	Magnesium oxide
NP	Nanoparticles
NACMC	Sodium carboxymethylcellulose
PAAm	Polyacrylamide
TEMED	N,N,N',N'-tetra-methylethylenediamine
XRD	X-ray diffraction

LIST OF SYMBOLS

R^2	R-Square
t	Time
S_t	Swelling at time t
S_e	Equilibrium swelling
W_t	Weight at time t
W_0	Initial weight
τ	Rate of swelling

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Hydrogel nanocomposites are cross-linked hydrophilic polymers containing nanoparticles having capacity to absorb, swell and retain large amount of water in their crosslinked networks. In particular, the hydrogel nanocomposites in which the hydrogel matrix is combined with inorganic nanoparticles (NPs) have gained much attention during the past few years. Nanostructured materials and nanoparticles are considered as significant types of materials which have obtained lots of interests in medical, catalysis, electronics, and optical applications (Ma and Zhang, 2008; Mohan *et al.*, 2006; Wang *et al.*, 2001).

In polyacrylamide based hydrogels, lots of applications have been found such as metal extraction and wastewater treatment. Cross-linked polymers which can imbibe large amount of water can be used in broad various fields such as biotechnology, biomedical engineering, food industry, water treatment and separation process. Due to

specific properties like considerable amount of swelling in water, biocompatibility, absorbing water easily or hydrophilicity, and non-toxicity, hydrogels can be used in various fields of biologic, medical, pharmaceutics and environment. In recent years, in order to remove dyes from aqueous solutions, cross-linked polymers which have functional groups like carboxylic acid, amine and hydroxyl were applied as removing agents (Karadağ and Saraydin, 2002).

1.2 Problem statement

Bacteria are Single-celled microorganisms which live all around us. They can exist either as independent organisms or as parasites. One of the different types of bacteria is Escherichia coli or E. coli which normally resides in the human colon. Most strains of E. coli are completely harmless, but some strains of it can cause diseases which sometimes lead to catastrophic results. For example, existence of E. coli in supply water in Walkerton, Ontario led to death of 18 people in the year 2000.

In recent years, using metal nanosystems have been an interesting issue due to their applications in antibacterial activities. The nanosize metals can be more effective in comparison with bulk metal; however, the most controversial issue is how to use these nanoparticles. In the last decades, some studies have demonstrated that the macroscopic gels can be a suitable template for in situ synthesis of nanoparticles.

Among metal nanoparticles which have been used as antibacterial agents, MgO has some advantages that prior it to other metals. Recently, the antibacterial characteristics of MgO nanoparticles have attracted many attentions. MgO is believed to

be highly inhibitive properties against bacteria (Sawai, 2003; Makhluf *et al.*, 2005; Nagappa and Chandrappa, 2007; Sawai *et al.*, 2000).

Moreover, it is predicted that magnesia or its mixtures with various inorganic materials will improve properties for different applications such as antibacterial activities. In addition, adding sodium carboxymethylcellulose to polyacrylamide will enhance abilities of hydrogel and antibacterial actions will be increased by this new hydrogel.

1.3 Research objectives

This research is aimed at:

- i. To formulate a new nanocomposite hydrogel for antibacterial applications.
- ii. To characterize the MgO nanocomposite hydrogel.
- iii. To evaluate the effect of synthesized hydrogel towards the inhibition of microbial activity.

1.4 Research scopes

This study is divided into four major scopes:

- i. Synthesizing of polyacrylamide/sodium carboxymethylcellulose hydrogels to be loaded with MgO nanoparticles.
- ii. Entrapping nanoparticles of MgO in the hydrogel network.
- iii. Characterization of the formulated hydrogels and studying the physical and chemical properties of gels as well as their microstructure.
- iv. Inhibition of E.Coli bacteria using loaded hydrogels.

1.5 Contribution of the study

The research suggests using MgO particles in nano size in polyacrylamide/sodium carboxymethylceloluse hydrogels in order to study its antibacterial effect. Also the study represents the physical and chemical characterizations of synthesized hydrogel.

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