STUDY ON THE EFFECT OF CELLULOSE LOADING AND pH ON WATER ABSORBENCY OF SUPERABSORBENT POLYMER COMPOSITE

NURHAFIZAH IZZATI BINTI KASIM

Thesis submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Chemical Engineering (Pure)

Faculty of Chemical & Natural Resources Engineering
UNIVERSITI MALAYSIA PAHANG

JULY 2014

ABSTRACT

Cellulose is natural polymer that can be found abundantly in the earth which has biorenewable and biodegrable abilities. Over the last several decades, the uses of synthetic polymers in all kind of applications and fields make the earth in the state of danger. As known, polymers material is difficult to dispose and can cause to environmental issues. Synthetic polymers wastes are the big problems that contribute to environmental and ecological damage. Therefore, the aim of this research is to increase the water absorbency of superabsorbent polymer by using the natural polymer which is cellulose as filler. It was believed that the incorporation of filler in SAP could increase the water absorbency of the polymer. In this study, the graft polymerization has been chosen to prepare the superabsorbent polymer composite (SAPC). The water absorbency property is observed by varied the filler loading contents and pH values. Based on the results obtained, the optimum of water absorbency of SAPC was shown at 2wt% of cellulose content. This 2wt% of SAPC was then immersed into acid and basic solution at different pH solution and the result shown the optimum water absorbency were observed at 2 wt% of cellulose loading. Meanwhile, the optimum water absorbency at different pH value also can be observed at both solution; acidic (pH 2) and basic (pH 12). For the effect of cellulose loading, the observed result was supported by SEM microstructures of SAPC where the surface morphology of SAPC at 2wt% of filler contents shown coarse, undulant surface and multiple porous. Meanwhile, the microstructure of SAPC at 10wt% show rigid and dense surface. The research objective has been successfully achieved in studying the effect of SAPC towards filler contents and pH values. As result, cellulose-SAPC (2.0 wt%) reveals with multiple porous structure that suitable for penetration of water into polymeric network. Meanwhile pH 2 and pH 12 are the optimum condition for water absorbency due to ionic charge strength from acidic and basic solution. Therefore, this research has proved that the cellulose SAPC was able to enhance the water absorbency of superabsorbent polymer which further could give better contributions in various applications and also more environmental friendly.

Key words: Cellulose, Superabsorbent polymer composite (SAPC), pH, Water Absorbency

ABSTRAK

Sellulosa adalah polimer semulajadi yang banyak ditemui di bumi yang mana boleh diperbaharui dan boleh terurai secara biologi. Sejak beberapa dekad yang lalu, kegunaan sintetik polimer dalam semua penggunaan dan bidang membuatkan bumi berada ditahap bahaya. Seperti yang diketahui, bahan polimer sangat susah untuk dilupus dan penyebab kepada masalah persekitaran. Bahan buangan daripada sintetik polimer merupakan masalah besar yang menyumbang kepada kemusnahan alam sekitar dan ekologi. Oleh itu, tujuan penyelidikan ini adalah untuk meningkatkan penyerapan air polimer penyerap lampau dengan menggunakan polimer semulajadi iaitu sellulosa sebagai pengisi. Dipercayai bahawa kehadiran pengisi dalam SAP boleh meningkatkan penyerapan air kepada polimer. Dalam kajian ini, polimerisasi telah dipilih untuk menyediakan komposit polimer penyerap lampau (SAPC). Ciri-ciri penyerapan air diperhatikan dengan mempelbagaikan kandungan pengisi muatan dan nilai pH. Berdasarkan keputusan yang telah diperolehi, penyerapan optimum air oleh SAPC telah ditunjukkan pada 2.0 wt % kandungan sellulosa. SAPC 2.0 wt% ini telah direndamkan kedalam larutan asid dan alkali pada larutan pH yang berbeza dan keputusan telah menunjukkan penyerapan air yang optimum telah dilihat pada 2 wt% kandungan sellulosa. Sementara itu, penyerapan air yang optimum pada nilai pH yang berbeza juga dilihat pada kedua-dua larutan pH; asid (pH 2) dan alkali (pH 12). Untuk kesan kandungan sellulosa, pemerhatian kepada keputusan telah disokong oleh SEM mikrostruktur SAPC dimana permukaan morfologi SAPC pada 2.0 wt% kandungan pengisi menunjukkan kasar, permukaan tidak rata dan mempunyai banyak rongga. Sementara itu, mikrostruktur SAPC pada 10.0 wt% menunjukkan permukaan yang tegap dan padat. SAPC telah dihasilkan dengan menggunakan teknik polimerasasi. Objektif penyelidikan ini telah berjaya mencapai dalam mengkaji kesan SAPC terhadap kandungan pengisi dan nilai pH. Sellulosa-SAPC (2.0 wt%) menunjukkan dengan mempunyai struktur yang banyak rongga yang sesuai untuk penembusan air kedalam rangkaian polimerik. Sementara itu, pH 2 dan pH 12 adalah optimum kondisi untuk penyerapan air disebabkan oleh cas kekuatan ionik daripada larutan asid dan alkali. Oleh itu, penyelidikan ini telah membuktikan yang sellulosa SAPC mampu meningkatkan penyerapan air polimer penyerap lampau dimana boleh memberi sumbangan yang lebih baik dalam pelbagai aplikasi serta mesra alam.

*Kata kunci:*Sellulosa, Komposit polimer penyerap lampau (SAPC), pH, Penyerapan Air.

TABLE OF CONTENTS

LIST OF FIGURES

Figure No. **Pages**

LIST OF TABLES

Figure No. **Pages**

LIST OF ABBREVIATIONS

AA	Acrylic Acid
AAm	Acrylamide
AM	Acrylamide
APS	Ammonium Persulpate
DI	Deionised
DP	Degree of Polymerisation
EFB	Empty fruit branch
FQA	Fiber quality analyzer
FTIR	Fourier Transform Infrared Spectroscopy
HCI	Hydrochloric Acid
LODP	Levelling-Off Degree of Polymerisation
MBA	N,N'-methylenebisacrylamide
N_2	Nitrogen
NaOH	Sodium Hydroxide
OPEFB	Oil Palm Empty Fruit Bunch
PAAm	Poly-Acrylamide
PAN	Polyacrylonitrile
PMMA	Polymethylmethacrylate
PVSA	Polyvinylsulfonic Acid
SAP	Superabsorbent polymer
SAPC	Superabsorbent polymer composite
SEM	Scanning Electron Microscopy
St	Starch
TGA	Thermogravimetric analysis
WRV	Water Retention Value
Wt	Weight

1 INTRODUCTION

1.1 BACKGROUND OF STUDY

Superabsorbent polymers (SAPs) are the materials that “attract” the water and have higher ability to absorb and retain huge amount water or aqueous solutions (Chen et al., 2008). The development of resin based on the starch grafting gives better results where it give higher absorption of water greater than 400 times its weight (Suda, 2007).The main applications of SAPs are disposable diapers and other applications including agriculture use. The SAPs can be classified into two classes based on the major mechanism of water absorption which are chemical and physical absorption (Zohuriaan-Mehr et al, 2008). In the early 1960s, the existence of superabsorbent polymer materials comes from the United States Department of Agriculture (USDA), as they are searching the material that able to improve water conservation in soils. Superabsorbent polymers received considerable attention for a variety of more specialised applications including matrices for enzyme immobilization, bioabsorbents in preparative chromatography, materials for agricultural mulches and matrices for controlled release devices (Hany 2007; Marcos et al., 2005). The superabsorbent materials then expand all over the world because of the demands with improvement in their properties which then widely used in many fields.

Recently the enhancement of technology shows some improvement in SAPs materials either from their properties, characteristics and also their uses. There are various of techniques or methods were used to synthesis higher quality of SAPs and one of it is grafting or cross-linked methods. Grafting or cross-linked the SAPs with other natural polymers such as cellulose is carried out to increase the absorbency of water. As known, cellulose is the organic substances that have very good biocompatibility such as biorenewable and biodegradable. According to previous work by Chen et al. (2008), cellulose is expected to be widely used in many applications and it most abundant biopolymer in the earth with low price polymer and good mechanical properties. Since there is increasing focus on the environmental issues associated with synthetic polymer, cellulose is the right choice an emerging tendency toward the use of natural polymer to improve bio-degradable properties instead of synthetic one (Hiroyuki et al., 2011).

According to Mahdavinia et al. (2009), the common method to synthesis of PAAm hydrogels is the free radical crosslinking copolymerization of AAm monomer with multifunctional vinyl monomers. PAAm hydrogels and their derivatives is the subject of many studies. PAAm hydrogels have proven capability of water absorption and biocompatibility with physiologic body fluids. The application of PAAm hydrogels in controlled release of agrochemicals and bioactive have been investigated by some researchers. From their research, it is reported that PAAm hydrogels has porous structure which has been synthesized using solution polymerization method in the presence of porogen (that produce gas bubbles from reaction of porogen with chemicals).

The aiming for grafting or cross-linked methods between superabsorbent polymers and cellulose in this study is to increase the absorbency of water by varied the filler which is cellulose filler loadings and pH values. The acrylamide (AAm) is going to use as monomer and ammonium persulfate (APS) as free radical and initiator in the synthesis of superabsorbent polymers. The expectation from this method is water absorbency will increase if the grafting yield also increases this is because the typical acrylic acid-based superabsorbent polymers will absorb water up to a 1000-fold of their weight (Buchholz 1994; Pan et al., 2011).

A great variety of hydrogels has been synthesized where the SAP can be made pH-sensitive or temperature-sensitive by using this method as well. Based on previous study, pH-sensitive poly (acrylamide-*co*itaconic acid) hydrogels were synthesized and influence of network parameters on the swelling and mechanical strength was analyzed. The results clearly demonstrate that network parameters are the key factors in controlling the behavioural changes in the properties of hydrogels. The swelling behaviour of poly (AA) hydrogels is highly dependent on the pH of the surrounding medium due to the presence of carboxylic groups. Polyvinylsulfonic acid (PVSA as sodium salt), which is a polyelectrolyte that has negatively charged sulfonate groups, is a blood compatible polymeric material. Due to negatively charged character of sulfonate groups, this polymer may be used as coating material (Talib et al., 2013).

1.2 MOTIVATION

Nowadays, the superabsorbent polymers (SAPs) are widely used in all around the world. SAPs have many applications in all kind of fields such as agriculture, horticulture, sanitary goods and medicine. The basic property of water absorption has suggested the use of SAPs in many other applications including paper towels, surgical sponges, meat trays and disposable mats for outside doorways and in bathrooms (Kiatkamjornwong, 2007). The main function of SAPs is to absorb any water or aqueous solution. Innovations are in fabrication of SAPs are keeping continuing in order to enhance the properties of SAPs. The widespread use of polymer in modern society has led to many advantages facilitating everyday life but also considerable disadvantages from the point of view of pollution and ecological damage and that the reason of cellulose had been chosen as filler in superabsorbent polymers (Shanahan et al., 1996). The synthetic polymer group are commonly contributed to pollution and ecological damage whereas natural polymer more safe and easily to dispose. Moreover, synthetic polymers that are derived from petroleum oil can cause the shortcomings for petroleum sources. Compare to natural polymer, it was generated from natural sources such as flax, hemp, pineapple wood, coconut and cotton (Alhuthali et al., 2011). Nowadays many things created by industrial highlighting on environmental friendly in reduce the pollution or environmental problems. Therefore, in this study, the cellulose has been used as filler in SAPs composite due to properties governed by cellulose.

This research also is designed to determine the effect of pH on superabsorbent polymer composite (SAPC) towards the water absorbency. So that, this research is exactly focused to increase the water absorbency and swelling properties of SAPC through the introduction of cellulose together with a target reducing the environmental problems and discover the new absorbent for SAPC. The significance from this research is the researcher will find the new material to increase the water absorbency for many applications and sectors especially for agriculture. Moreover, this research also can prevent the environmental problem and low cost products that directly produce the green products.

Since SAP as a soil conditioner, the application of cellulose-SAP is very important in agriculture and cost such as reduce watering frequency and help to retain nutrient from fertilizer. The insoluble and soluble polymers have been used in agriculture. Water soluble polymers such as polyacrylamides (PAM) have been used extensively to stabilize the soil structure and thus increase infiltration and reduce runoff and erosion. Insoluble water-absorbing and gel-forming ability such as the acrylamide-acrylate co-polymers which are sometimes marketed for agriculture because of their great capacity to expand and absorb water under pressure, thus not only providing plants with water, but also helping to aerate the soil (Shahidian et al., 2000).

1.3 RESEARCH OBJECTIVE

The main objectives of this research are to study the optimum conditions of cellulose based on the superabsorbent polymer composite by determining:

a) Effect on amount of cellulose loading towards water absorbency
b) Effect on different of pH solutions towards water absorbency.

1.4 SCOPE OF STUDY

In this research, the cellulose is used as the main material for grafting with superabsorbent polymer (SAP) in order to produce superabsorbent polymer composite (SAPC). There are two parameters that will be varied in this study which were the amount of filler (Cellulose) and pH solutions. The objectives of this research are to investigate the effect of cellulose-graft-superabsorbent polymers (SAPs) and pH values towards the water absorbency. In preparation of buffer solutions, types of acid and alkali that are used to prepare the buffer solutions are hydrochloric acid (HCI) and sodium hydroxide (NaOH). The water absorbency of SAP and SAPC was determined or tested by tea bag method which originally introduced by Japan Company. The characterization of SAPC then was determined by using FTIR spectroscopy and the surface morphological studies were conducted by scanning electron microscopy (SEM). Meanwhile the thermal stability forward increasing temperature will be analysed by Thermogravimetric Analysis (TGA).

2 LITERATURE REVIEW

2.1 CELLULOSE

Cellulose is the world's most common biopolymer and such will play a growing role as society confronts the problems of climate change and declining stocks of fossil fuels. The discovered of cellulose shown that biopolymer got important and fascinating molecules or particles. Generally, cellulose is along chain polymer that linked together with repeating units. Cellulose usually comes from natural such as plant since it is natural polymers but cellulose is also produced by some algae, bacteria, fungi, protozoans and animal tunicates. There is more cellulose in the biosphere that any other substance. There are various structures and properties of cellulose that makes this special polymer is used as filler in this research. The properties of cellulose depend on its molecular and morphological structures besides it also have mechanical, physical, environment and nano-materials properties (Luc Wertz, 2010).

Cellulose is a biodegradable and non-toxic solid polymer. Its biodegradation is an essential step in the carbon cycle, which ensures the carbon balance in the biosphere. Moreover, cellulose is not thermoplastic and insoluble in water and most organic solvents. The polymer does swell, however in many polar liquids including water. Cellulose is a hygroscopic substrate which absorbs 8 to 14% water at 20^{o}C and 60% relative humidity. Cellulose-water interaction plays a central role in cellulose isolation and processing, as well as in paper making. Cellulose exhibits high hygroscopy resulting from interacting between its OH groups and water molecules, but is not dissolved in water because the cellulose molecules prefer their equals to water. Cellulose-water interaction can be described as a competition in hydrogen bonding between cellulose OH groups on one side and cellulose OH groups and water molecules or clusters on the other side (Luc Wertz, 2010).

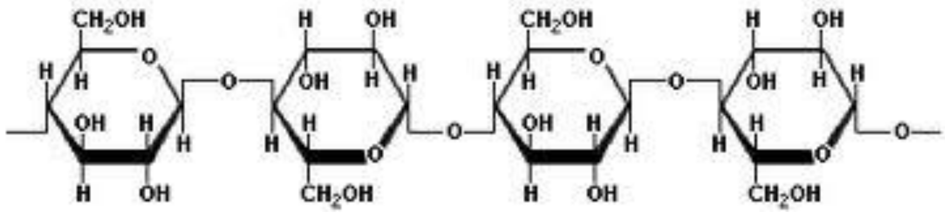

Figure 2.1 : Chemical structure for cellulose (Luc Wertz, 2010).

2.2 SUPERABSORBENT POLYMER COMPOSITE (SAPC)

Superabsorbent polymer also known as hydrogels which are macromolecular networks able to absorbs and release water solutions in reversible manner, in response to specific environmental stimuli (Alessandro et al., 2009). Superabsorbent polymers can be explain and elaborate as having a network structure and a moderate degree of crosslinking (Omidian et al., 2005). They can absorb a large amount of water, considerably more than their dry mass. The amount of the absorbed water can range from hundreds of times to thousands of times of polymer (Chen et al., 2008). Hydrogels are able exhibit the ability of swelling in water and retaining a significant fraction where more than 20 percent of water within their structure, without dissolving in water. However, hydrogels also has absorption limit where their capacity of absorption is not more than 100 percent (1g/g) (Zohuriaan-Mehr and Kurosh kabiri, 2008). These hydrogels are widely use in the disposable hygienic products such as napkin and diapers, in agriculture, biomedical and food packaging (Kono and Fujita, 2011; Shaobo et al., 2011; Ping-Sheng Liu et al., 2009). The ability of the SAP or swollen hydrogel to release water to the surroundings as vapour has also been used in most various ways for examples, as humidity-controlling products or as soil conditioners (Kiatkamjornwong, 2007).

According to Zohuriaan and Kabiri (2008), the hydrogels as superabsorbent materials are usually can be classified into two main classes based on the major mechanism of water absorptions either chemically and physically absoprtions. Chemical absorbers catch water via chemical reaction converting their entire nature where physical absorbers imbibe water via four main mechanisms:

i. Reversible changes of their crystal structures
ii. Physical entrapment of water via capillary forces in their macro-porous structure
iii. A combination of the mechanism and hydration of functional group
iv. The mechanism which may be anticipated by combination of mechanisms of hydration of functional group and a combination of the mechanism and essentially dissolution and thermodynamically favoured expansion of the macro-molecular chains limited by cross-linkages.

Generally known that superabsorbent polymer (SAP) absorbs water through the hydrogen bonding with water molecules and due to osmotic pressure. Most SAPs are produced by aqueous phase polymerization of acrylic acid in the presence of a crosslinking monomer and initiator. Those happened because charge neutralization of the acid groups is accomplished with base either pre or post-polymerization depending on the type of reactor and reaction condition (Pan et al., 2011). The superabsorbent polymer composite (SAPC) synthesized from crosslinking between acrylamide (AAm) which is act as monomer and ammonium persulphate (APS) as initiator which is theoretically, there is wide range of inorganic materials with expandable layers available for utilization for the preparation of SAPC. The superabsorbent polymer composites (SAPC) find many new applications beyond those superabsorbent polymers (SAPs), such as nanocomposites materials, for example fabrication of silver or zinc nanoparticles in SAP or SAPC networks. The proven applications are for catalysis, optics, electronics, bio-medicals and quantum-sized domain applications besides some potential application of SAPC in water treatments (Kiatkamjornwong, 2007).

2.3 POLYMERIZATION TECHNIQUES

Polymerization techniques is the one of the techniques that used to form the free radical monomer to ensure the next reaction can be occurs. There are several types of polymerization techniques to produce free radical such as solution polymerization, suspension polymerization and irradiation. In this research, solution polymerization has been chosen to produce free radical monomer between the superabsorbent polymers (SAPs) with cellulose in order to produce superabsorbent polymer composite (SAPC).

The polymerization techniques or also known as crosslinking techniques is the important techniques and has been widely used to prepare the certain copolymers. Crosslinking of synthetic polymer is a convenient method to add new properties with minimum loss of initial properties of the SAP. According to Feng et al., (2008), ceric ion initiation, Fenton’s reagent and ɤ-radiation are widely used methods to graft monomers to cellulose. However, there are some drawbacks of these methods, such as the production of unwanted homopolymer together with the graft copolymer and chain degradation of the cellulose backbone during the formation of free radical grafting sites.

In solution polymerization or also known as crosslinking reactions, the ionic or neutral monomers are mixed with multifunctional cross-linking agent. The polymerization is initiated thermally, by UV-irradiation or redox initiator system. The presence of solvent serving as a heat sink is the major advantage of the solution polymerization over the bulk polymerization. After the phase separation occurs and the heterogeneous SAP is formed when the amount of water during polymerization is more than the water content corresponding to the equilibrium swelling. This is straight forward process and by using this method, the high versatility of hydrogels has been synthesized the solution polymerization is a straight forward process.

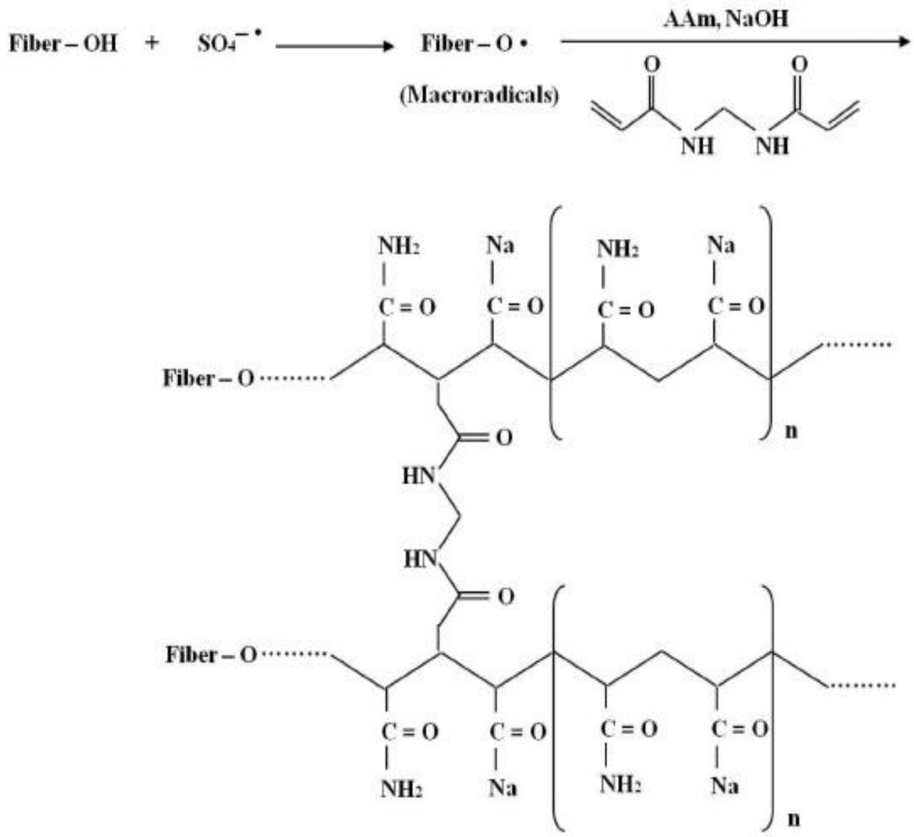

Figure 2.2 : Proposed Mechanism Pathway for Synthesis of OPEFB-g-PAAm SAPC (Shafinaz and Shahrir, 2011)

2.4 FACTORS THAT INFLUENCE PROPERTIES OF SUPERABSORBENT POLYMER (SAP)

Water absorbency or also known as water retention value (WRV) is defined as the ratio of water to dry cellulose after centrifugation of water swollen cellulose substrate under standard condition. It is used to measure of the swelling of cellulose in water and can also constitute a means of measuring changes in accessibility of cellulose following various swelling treatments (Luc-Wertz, 2010). The degree of polymerization (DP) is directly proportional with water absorbency level where it is one of the most great influenced towards the SAPs itself (Hiroyuki Kono et al. 2011). This is because, a sharp degree of polymerization (DP) has been generally attributed to degradation in the easily accessible of a SAP. The slow degradation stage was characterized by relatively small DP changes, especially after reaching the so-called levelling-off DP (LODP). Besides that, the size and the length of the polymer chains of the SAPs also one of the contributor factor in enhancing the water absorbency (Buchholz and Graham, 1997, Liu and Rempel, 1997).

The properties of superabsorbent polymers can be influenced by many factors such as bulk density, pH, degree of neutralization, pressure rate and also weight (W. Bai, 2010). The synthesized of SAP based on starch (St) and polyacrylonitrile (PAN) in the research of Sadeghi and Hosseinzadeh (2008), give effects of the hydrolysis reaction variables on the swelling properties, as well as the salt and pH sensitivity of the hydrogel. The swelling capacity of the hydrogel was also greatly influence by the alkaline hydrolysis time. The reaction period (the time after addition of PAN to the mixture) varied from 30 to 180 minutes. The water absorbency increased as the alkaline hydrolysis time increased, up to 90 min (545 g/g) and then it decreased with further extension of the reaction time. It is obvious that increasing the alkaline hydrolysis time increases the extent of the reactions between the nitrile groups including those of the adjacent pendant. Meanwhile, according to Shafinaz & Shahrir (2011), the water absorbency increase with the increase of degree of neutralization from 10% to 20% and decreased with further increase up to 40%.

Figure 2.3 shows the illustrations of an acrylic-based anionic superabsorbent hydrogel in the dry and water-swollen states. The collapsed chains in the dry state superabsorbent polymer composite (SAPC) will be expanded when it is immersed in aqueous solution. It shows that superabsorbent can retain huge amount of aqueous solution even under certain pressure.

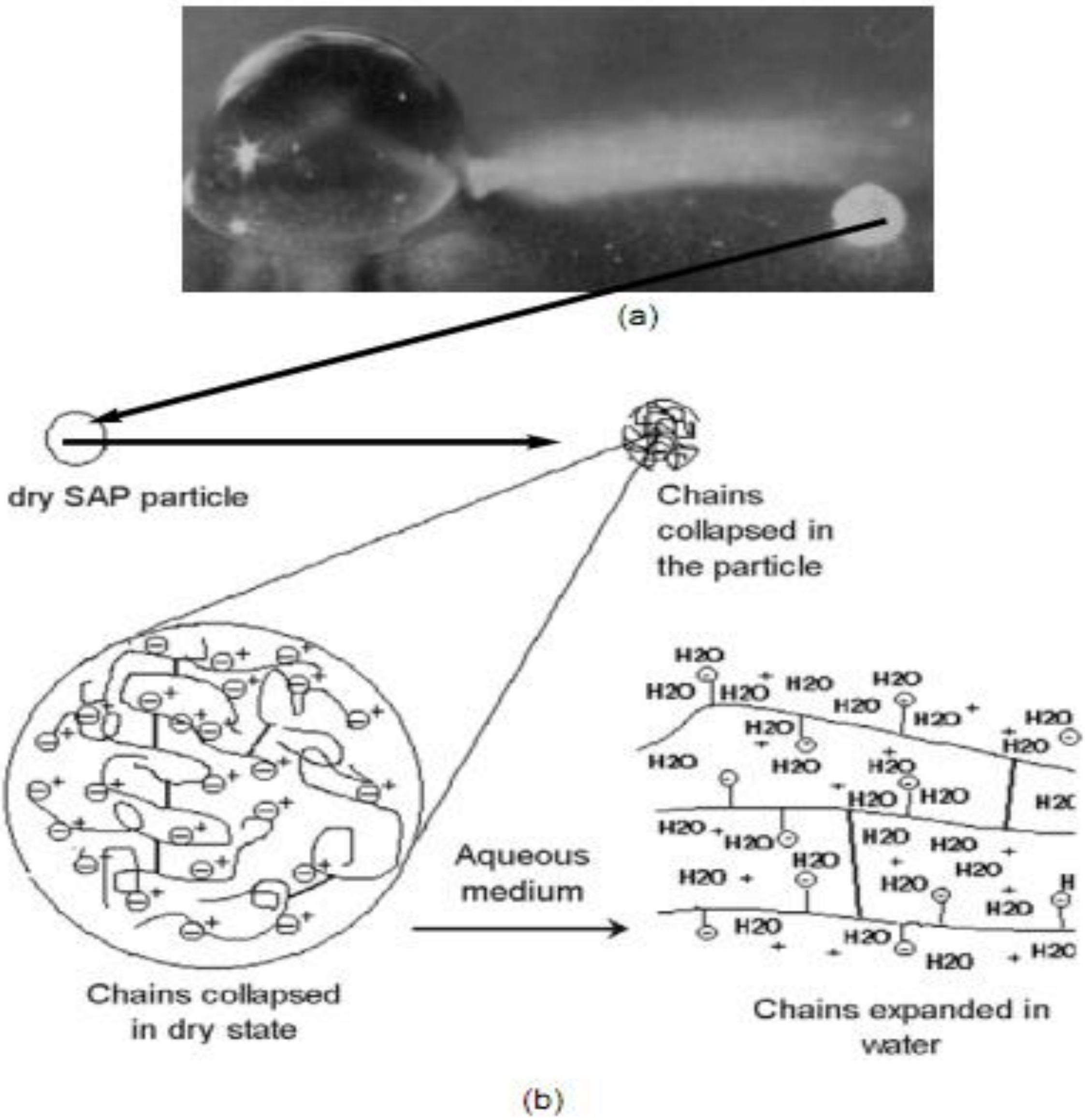

Figure 2.3: Illustration of a typical acrylic-based anionic SAP material in the dry and water-swollen states.

(Zohuriaan & Kabiri, 2008)

2.4.1 Influences of pH Solution

In the cellulose superabsorbent polymer, there are interactions between the different ions. According to Ali et al., (2006), the swelling ratio is mainly related to the characteristics of the external solution such as charge number and ionic strength, as well as the nature of polymer like elasticity of the network, the presence of hydrophilic functional groups and the extent of crosslinking density. For instance, swelling ability of “anionic” hydrogels in various salt solutions is appreciably decreased comparing to the swelling values in distilled water. This well known undesired swelling loss is often attributed to a “charge screening effect” of the additional cations causing a non-perfect anion-anion electrostatic repulsion. In addition, in the case of salt solutions with multivalent cations, “ionic crosslinking” at surface of particles causing an appreciably decrease in swelling capacity.

Since the swelling capacity of all “anionic” hydrogels is appreciably decreased by addition of counter ions (cations) to the swelling medium. Therefore, stock NaOH (pH 13.0) and HCI (pH 1.0) solutions were diluted with distilled water to reach desired basic and acidic pH values. Maximum swelling (746g/g) was obtained at pH 7. Under acidic pH values, most of the carboxylate anions are protonated, so the main anion-anion repulsive forces are eliminated and consequently swelling values are decreased. At higher value of pH (pH 5-7), some of carboxylates groups are ionized and the electrostatic repulsion between COO^- groups causes enhancement of the swelling capacity. Again, a charge-screening effect of the counter ions (cations) limits the swelling at pH>7. Similar swelling pH dependencies have been reported in the case of other hydrogel systems.

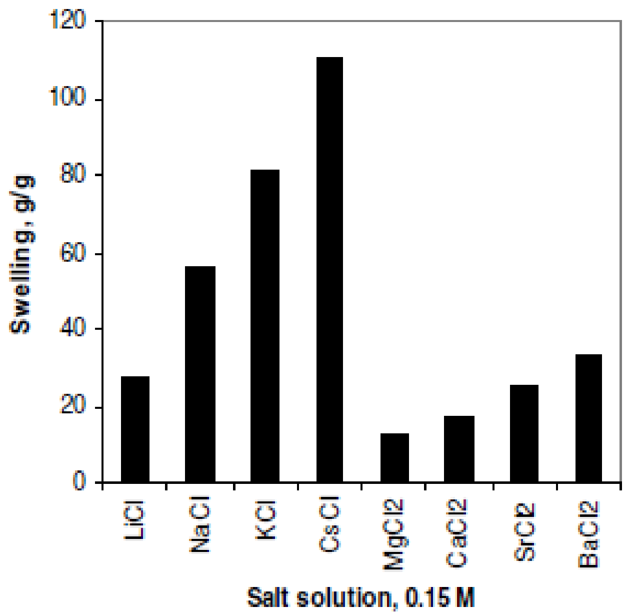

Figure 2.4: Swelling capacity of the partially neutralized collagen-g-PAA hydrogel in different chloride salt solutions (0.15M)
(Ali Pourjavadi et al., 2006)

Based on the previous study by Fatemah and Sadeghi (2012), the NaOH (pH 10.0) and HCI (pH 1.0) solutions were diluted also using distilled water to reach desired basic and acidic pHs, respectively. Maximum swelling (95g/g) was obtained at pH 8. In acidic media, most carboxylic acid groups are protonated, so decreased repulsion of anionic groups leads to decreased swelling ratio. At the higher pHs (pH 5-8), some carboxylate are ionized and the electrostatic repulsion between carboxylic groups causes an enhancement of the swelling capacity. The reason of the swelling loss for the highly basic solutions is the charge screening effect of excess Na^+ in the swelling media, which shield the carboxylate anions and prevent effective anion-anion repulsion. Similar swelling-pH dependencies have been reported in the case of other hydrogel system.

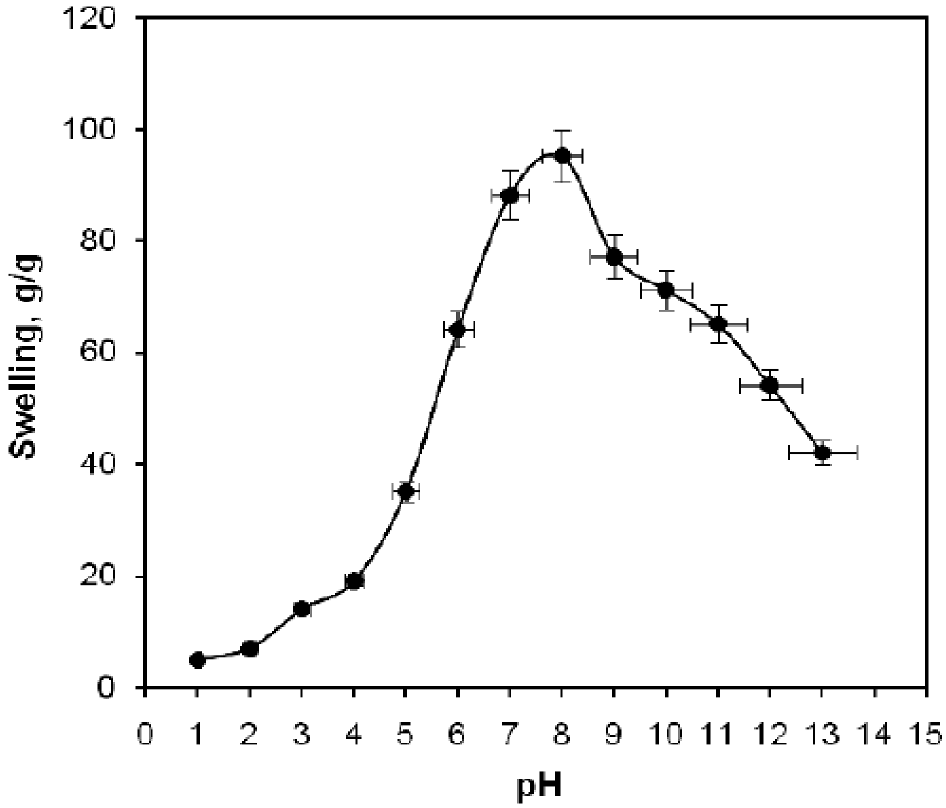

Figure 2.5: pH dependent swelling of the superabsorbent hydrogel

.

(Fatemah and Sadeghi, 2012)

2.4.2 Effect of initiator

Initiator or activator has same “role” and both are very important in gaining the great polymerization and crosslinking method or process. It also plays role in the degree and molecular weight for two points (Murthy et al., 2006). For this research, ammonium persulphate (APS) act as initiator in synthesize SAPC and used to investigate the effect water absorbency towards the initiator. According to Ibrahim et al., 2003 & 2005, the extent of grafting increases with the amount of initiator and up to certain limit then the graft will decrease. When increasing the initiator concentration, the free radicals also increase, which it will be enhanced the possibility of initiating reactive site of backbone where pomethylmethacrylate (PMMA) can be grafted. The effect of the amount of initiator is the percentage of grafting increased with an increase of the amount of initiator but decreased at higher amount. So, from this research, the optimum amount of initiator can be determined.

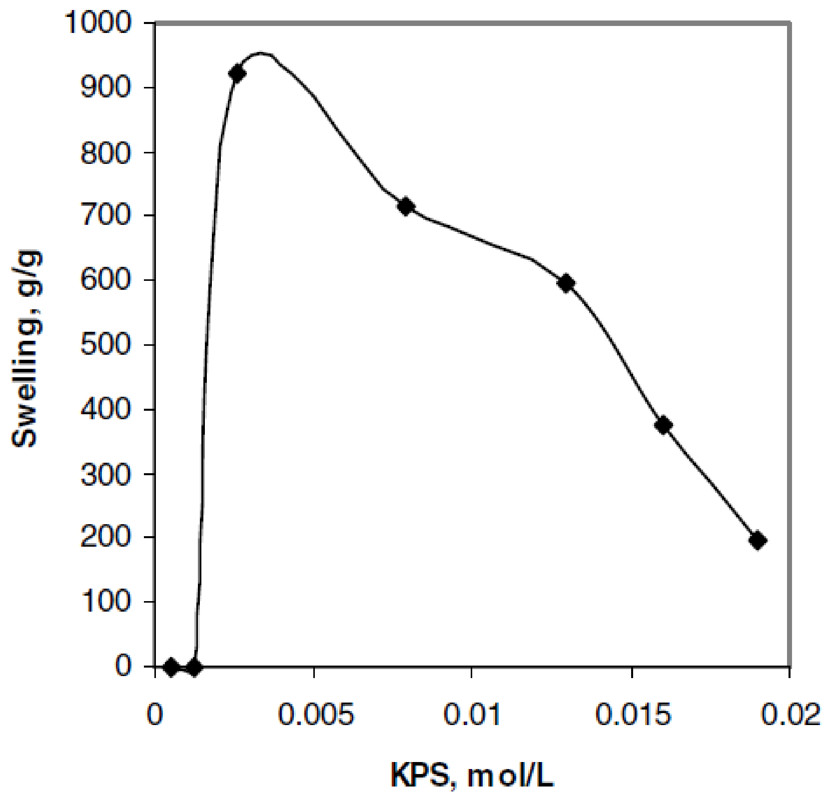

Figure 2.6: Effect of initiator on water absorbency

(Pourjavadi et al., 2011)

2.4.3 Effect of crosslinker

Crosslinker are necessary in crosslinking process in order to "hold" the hydrophilic polymer chain from dissolve and it also help to form the hydrogels or SAPC by absorbing water. The molecular weight and density of the crosslinker are factors that influence water absorption in the SAPC (Reens Singhal, 2009). From the research of Gerald (2011), the mechanical strength increases with AAm content and water absorptions of SAPC in the soils rapidly decreases. This is due to formation of additional crosslink with other certain ions. Water absorption decrease whenever the increasing amount of AAm content because increasing amount of crosslinker means increasing number of polymer chain in the SAPC which directly cause the decreasing water absorbency. Therefore, less water molecules are able to enter the SAPC due to lower available volume.

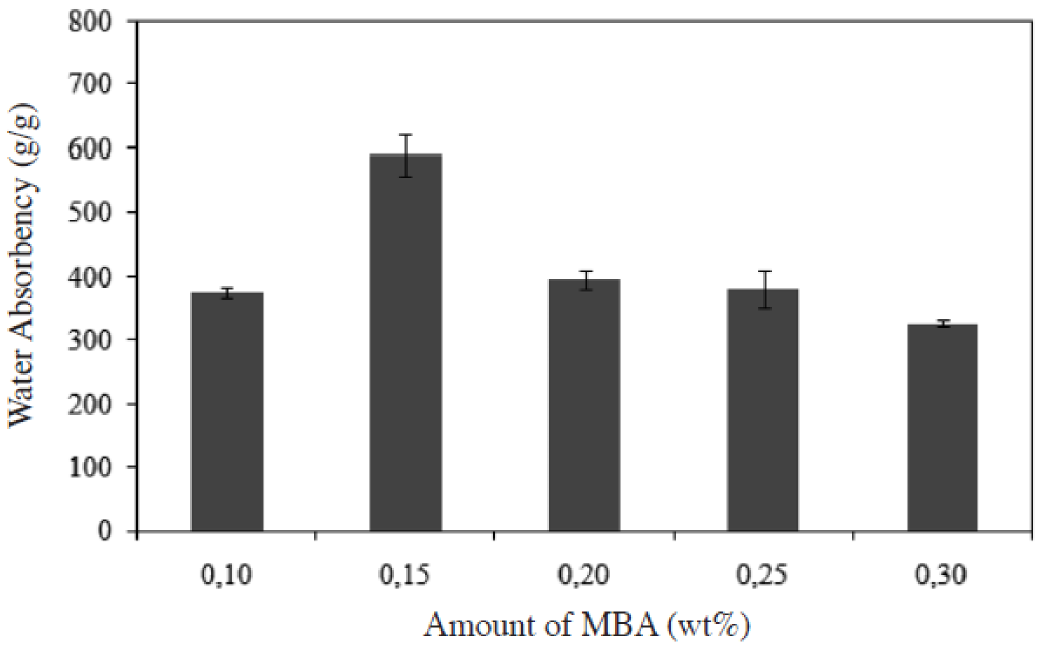

Figure 2.7: Effect of crosslinking on water absorbency

(Shafinaz and Shahrir, 2011)

2.4.4 Effect of filler

Besides crosslinker and initiator, the filler also play the important role in the synthesis of superabsorbent polymer composite (SAPC) and for this research, the cellulose is chosen as the filler. Recently, the most famous filler that used in the synthesizing SAPC is empty fruit bunch (EFB) of palm oil. This is because EFB very cheap in price and have higher availability as Malaysia is the larger producer of palm oil (Bala Ramasamy, 2005). Majorly EFB was used as filler because it can reduce the solid waste that produced by palm oil mills and directly can prevent the pollution to the environment.

Based on the previous work by Shafinaz and Shahrir (2011), the Oil Palm Empty Fruit Bunch (OPEFB) give effect to the content of water absorbency for the synthesized superabsorbent composite (SAPC). It can be seen that the water absorbency of SAPC incorporated with 10 wt% OPEFB, absorbed almost the same amount of water with PAAm SAPs. OPEFB work as another crosslinking points besides as biodegradable material that exists in the synthesized SAPC system. At 5 wt% off OPEFB, the amount of OPEFB does not provide enough crosslinking point within the SAPC polymeric network space. Thus, the water absorption capacity was lowered. However, as the loading increases near 10 wt%, the ability of water absorbency was enhanced, due to the OH molecules on the OPEFB backbone could react with AAm monomer, which benefit the system by forming a network structure. When the amount of OPEFB is suitable for the system such as 10 wt% OPEFB, the crosslink density and the network space of the SAPC were almost similar to that pristine one resulting in almost the same capacity in water absorbency.

In this research, the cellulose had been chosen as filler because their characterization is able to enhance the water absorption in the superabsorbent composite (SAPC). Besides it is natural polymers where lead to environmental friendly, it also cheap in cost therefore offers benefits for use in commercial applications (Alhuthali et al., 2011). The flexibility of cellulose are able improve the properties either in chemically or physically.