

# OPEFB Filler from Biomass in Superabsorbent Polymer Composite for Agriculture Application: A Comparative Study

Wan Siti Nadiah Wan Yaacob, Saidatul Shima Jamari  
and Suriati Ghazali

**Abstract** An agriculture activity is one of the major sectors which contribute a significant share to Malaysia economy. Therefore it is important to maintain the soil fertility. Superabsorbent polymer composite (SAP'c) was produced using graft polymerization technique with the addition of the oil palm empty fruit bunch (OPEFB) filler to enhance the absorbance properties and decomposition process. Effect of filler addition at different size to the SAP'c was investigated. Water absorbency test was conducted to determine the absorbency and swelling properties while Fourier Transform Infrared (FTIR) and Scanning Electron Microscopic (SEM) analysis was conducted to investigate the functional groups and morphology of the SAP'c. Water absorb highest for SAP'c with coarse OPEFB while fine particle size showed a decrement in swelling behaviour. FTIR spectra shows that  $-C \equiv C-H$  with  $C-H$  bend existed in all samples. SEM showed that the addition of the OPEFB give a fibrous morphology and build a surface contact. In conclusion the addition of biomass filler in the superabsorbent polymer (SAP) will increase the water absorbency and swelling properties of the hydrogel.

**Keywords** Superabsorbent polymer • Superabsorbent polymer composite • Oil palm empty fruit bunch

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W.S.N.W. Yaacob • S.S. Jamari (✉) • S. Ghazali  
Faculty of Chemical and Natural Resources Engineering, Universiti Malaysia Pahang,  
Lebuhraya Tun Razak, 26300 Kuantan, Pahang, Malaysia  
e-mail: sshima@ump.edu.my

W.S.N.W. Yaacob  
e-mail: wan\_nad90@yahoo.com

S. Ghazali  
e-mail: suriati@ump.edu.my

## Introduction

Nowadays, agricultural activities are becoming a major growing sector and contribute a lot of income to the Malaysia economy. In addition, this activity also provides employment opportunities to the citizen. In order to ensure that agricultural activities continues to contribute significantly, measures should be taken to safeguard the sustainability of this sector, for example, to maintain the soil fertility. Fertilizers made from chemicals are beneficial towards the plant however, offer adverse effects to the neutrality of the soil pH. Therefore, this research was proposed to synthesis SAP's as a soil conditioning mechanism.

In 1960s, the United States Department of Agriculture has developed superabsorbent polymer. The early attempt for the commercialization of superabsorbent polymer was in early 1970s as it is commercialized in the form of starch/acrylonitrile/acrylamide based polymer (superslupers). At first, this material was focused to be used in agriculture/horticulture sector. In 1982, superabsorbent polymer for the diapers application were introduced to the Japanese market by Unicharm, while in 1983 by KAO and Procter and Gamble introduced in 1985, [1, 2]. In general, the definition of superabsorbent polymer is a material that can absorb huge amount of water while retain its original shape without loss the water that had been absorb. The example applications that used this type of materials were in hygiene product such as diapers. The most common technique to synthesize this material was by graft polymerization method. In graft polymerization method, usually acrylic acid or methacrylic acid was used as monomers and sometimes acrylamide and methacrylamide also can be used. The addition of acrylamide into acrylic acid can help to increase the absorbency of superabsorbent polymer besides induce the graft polymerization [3].

Currently, the world major concern is towards the environmental problems. In relative to the problem, superabsorbent polymers composite, which produce throughout the research, were synthesized by adding the OPEFB from biomass waste as filler. The addition of the OPEFB will enhance the biodegradable ability thus it will be an eco-friendly product. Employing a biomass waste as filler will reduce the land pollutant cause by the waste besides reducing the cost needed to decompose the waste and production cost of the product. In recent years, Malaysia has become the second largest (after Indonesia) palm oil exporter thus contributes up to 39 wt% of the total world palm oil production. Due to the demand of the palm oil industries around the world, few countries such as Indonesia, Colombia, Ivory Coast and Papua New Guinea had identified other good potential of the palm oil resulting in increasing of the fresh fruit bunch (FFB) production that leads to the increasing of waste streams [4].

As the OPEFB is one of the main waste biomass products in Malaysia, Malaysian Palm Oil Board (MPOB) in 2005 has record that about 20–25 % residue of OPEFB produced for every tonne FFB after it was steamed and fruitlets are removed. Study done before on the ten years application of empty fruit bunches in an oil palm plantation on soil chemical properties showed that the decomposition

time of OPEFB was decreased when it is applied to soil. Within 7–15 weeks of decomposition process, empty fruit bunch (EFB) has lost its dry matter up to 50 % with the total decomposition of dry OPEFB in the soil only taking less than 12 months. Other than that, the application of OPEFB in soil has increased the pH value of the soil [5]. So that, the application of OPEFB as a biomass filler in superabsorbent polymer will help in naturally for the polymer chain to decompose itself in soil besides increasing the fertility of the soil as the OPEFB helps to increase the pH value of the acidic soil.

## **Materials and Experimental**

### ***Materials***

OPEFB was chosen as biomass filler in SAP<sup>c</sup> composites. For synthesis of SAP<sup>c</sup>, AA was used as a monomer, MBA as a crosslinker agent while APS was used as an initiator.

### ***Experimental***

#### **Preparation of OPEFB as a Filler**

Fresh OPEFB were cut into small pieces and dried in an oven for 5 days at 70 °C. After that, high speed grinder was used to reduce the size of dried OPEFB. Grinded OPEFB particles were then sieved to get a uniform particle size.

#### **Synthesis of SAP<sup>c</sup>**

SAP<sup>c</sup> was synthesized by using graft polymerization method. In an empty three neck flask, acrylic acid solution was prepared. Then, sodium hydroxide (5 M) was added to neutralize the acrylic acid solution and OPEFB was added as the filler. Mixture was continuously stirred throughout the process and crosslinking agent (MBA) was added under a nitrogen atmosphere. After 30 min of stirring, APS was added into it and temperature slowly raised up to 70 °C. SAP<sup>c</sup> gel will be formed after 30 min of reactions. All the reactions were carried out using double boil technique. The obtained gel was then washed using distilled water for several times and dried in an oven at temperatures, 70 °C for 24 h. Dried SAP<sup>c</sup> was then milled to small particles (powder form). Similar step was repeated for pure SAP<sup>c</sup>, without the addition of OPEFB filler.

## Water Absorbency Measurement

0.53 g of SAP'c was weighed and added into a tea-bag. The tea bag was then immersed in a 1 L distilled water at room temperature. SAP'c will slowly swell until the equilibrium is reached. After 24 h, swollen gel was allowed to drain and reweighed to calculate its water absorbency by using the following equation.

$$\text{Water Absorbency, } Q\left(\frac{g_{H_2O}}{g_{sample}}\right) = \frac{m_2 - m_1}{m_1}$$

Water absorbency is expressed in grams of water stored in gel by a gram of dried gel.  $m_2$  and  $m_1$  represents the weight of gel after immersed in water and weight of dried gel before immersed in water. The test was repeated for three times.

## Results and Discussions

### Water Absorbency Test

Water absorbency test was carried out for 24 h to observe and determine the swelling capacity of the all SAP'c. Table 1 shows that the weight of all samples is increased up to 200 times from the original weight. The application of the OPEFB filler has increased the swelling capacity. However, the particle size gave effect to the swelling behavior of the SAP'c. It showed that SAP'c with a coarse OPEFB can absorbed more water with the water absorbency increment up to 0.94 % but SAP'c with fine OPEFB decreased to 5.82 %, compared to the pure OPEFB. Refer to the Sadeghi et al. studied on the swelling behavior of the SAP, dense crosslinking in SAP'c can decrease the swelling behavior of the hydrogel. It is due to the higher crosslinking density has decreased the space between the copolymer chains thus resulted in the rigid structure that cannot be expanded and hold large amount of water [6]. So in this case, fine particle size give a large surface area for the OPEFB to make contact and crosslink with the copolymer thus increased the crosslinking density of SAP'c.

**Table 1** The weight of SAP'c before and after the water absorption test

Samples	Pure SAP'c	SAP'c with coarse OPEFB	SAP'c with fine OPEFB
Initial weight (g)	0.53	0.53	0.53
Final weight (g)	115.55	116.62	108.85

## FTIR Analysis

FTIR analysis has been carried out to determine the functional group that exists in OPEFB and SAP'c. As shown in Fig. 1, there is a strong and broad OH-stretch with H-bonded at the band  $3420.87\text{ cm}^{-1}$ . At the spectra with medium peak of  $2920.43\text{ cm}^{-1}$ , C–H with asymmetric and symmetric stretch (alkanes group) formed while at the band of  $1738.42$ ,  $1639.33$ , and  $1055.21\text{ cm}^{-1}$ , there is C double bond O stretch, medium peak of N–H bend in amines-primary group and medium C–N stretch in aliphatic amines group for OPEFB sample.

The comparison of FTIR spectra in Fig. 2 for the three samples of SAP'c before immersed in water showed that at peak  $3425.52\text{ cm}^{-1}$  for pure SAP'c, the peak shift

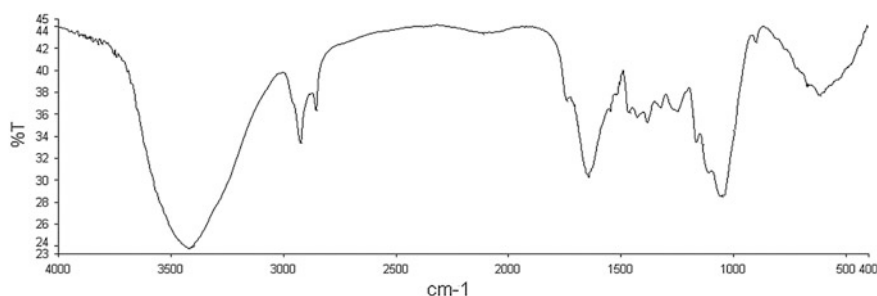


Fig. 1 FTIR spectra for OPEFB

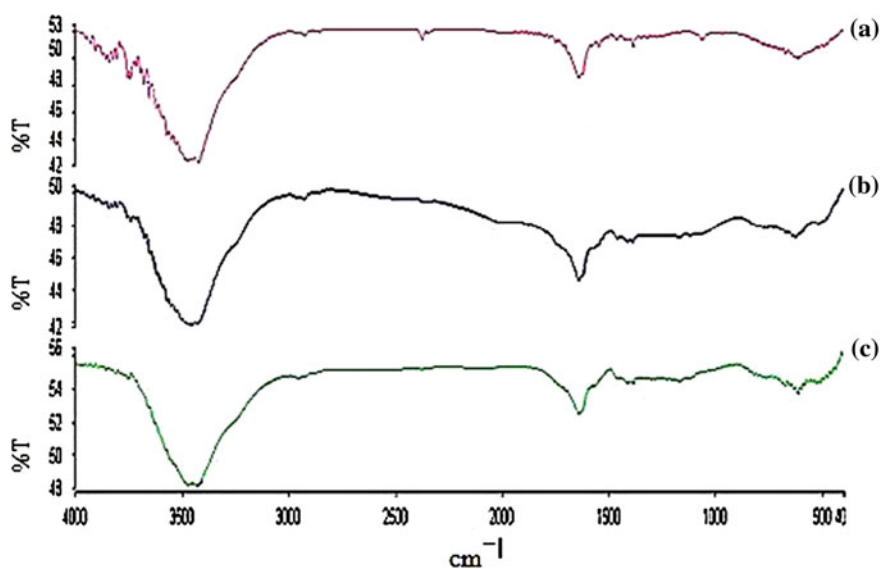
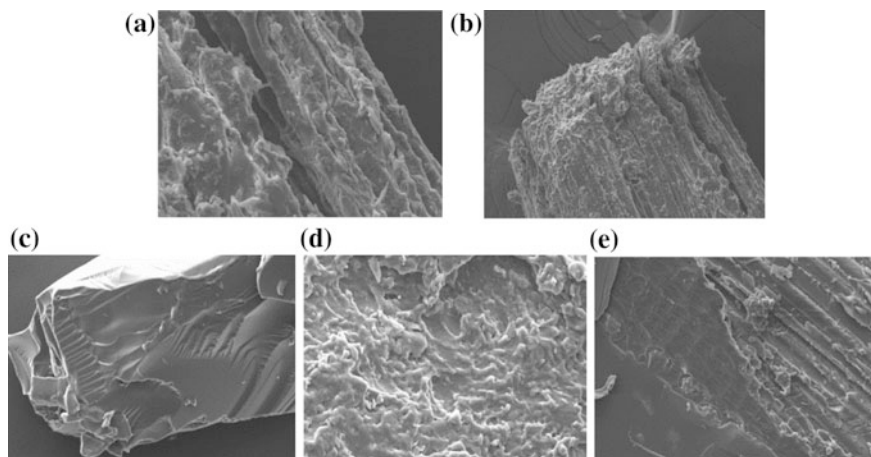


Fig. 2 FTIR spectra for **a** SAP'c with coarse OPEFB size **b** SAP'c with fine OPEFB size **c** pure SAP'c

to  $3464.64\text{ cm}^{-1}$  for the SAP'c with the fine size of filler and for the coarse filler size, the peak shift back to  $3420.61\text{ cm}^{-1}$ . This peak shows the existence of strong and broad O-H stretch with H-bonded. These bonds indicate the presence of  $\text{-OH}$  group in the samples. For all three samples, N-H and N = O bending at peaks  $1637.38$  and  $615.00\text{ cm}^{-1}$  for pure SAP'c,  $1639.19$  and  $621.78\text{ cm}^{-1}$  for SAP'c with fine filler and for SAP'c with coarse size filler was at  $1639.19$  and  $1384.55\text{ cm}^{-1}$  and also  $\text{-C}\equiv\text{C-H}$  with C-H bend exist for three samples at peaks in range between  $614.00$  and  $621.8\text{ cm}^{-1}$  indicates that the graft polymerization occurs in all samples and AA was grafted to the OPEFB during the graft polymerization reaction occurs [7].

### Surface Morphology Analysis Using Scanning Electron Microscopy (SEM)

From the SEM analysis, it can be seen that the addition of the OPEFB as a filler in SAP'c able to increase the space capacity in the SAP'c as the parallel alignment of the OPEFB help the water to absorb faster and thus occupied the gel space. Compared Fig. 3c, e the addition of the OPEFB give a fibrous morphology and build a surface crosslinking thus enhance the absorption ability of the SAP'c gel.



**Fig. 3** Surface morphology of **a** coarse OPEFB **b** fine OPEFB **c** pure SAP'c **d** SAP'c with fine OPEFB **e** SAP'c with coarse OPEFB

## Conclusion

In conclusion, superabsorbent polymer composite can be synthesized by using graft polymerization techniques. The application of well distributed OPEFB in SAP<sup>c</sup> will enhance and optimize the absorbency and swelling properties of SAP<sup>c</sup>. However, it is important to choose the suitable particles size to prevent SAP<sup>c</sup> from losing their good absorbency and water retention characteristics.

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ICGSCE 2014

Proceedings of the International Conference on Global  
Sustainability and Chemical Engineering

Hashim, M.A. (Ed.)

2015, XIV, 421 p. 177 illus., 130 illus. in color.,

Hardcover

ISBN: 978-981-287-504-4