MODIFICATION OF OIL PALM EMPTY FRUIT BUNCH FIBER BY GRAFT COPOLYMERIZATION

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Introduction

Oil palm empty fruit bunch (OPEFB) fiber is a lignocellulosic fiber which is obtained after stripping off the fruits from fruit bunches for the extraction of the oil. Commercial exploitation of this fiber is now being actively carried out since it is abundant and regarded as a waste. Many modification techniques of OPEFB fiber have been proposed to impart new properties so that their applications can be improved or diversified. One of the effective methods of chemical modification of natural fibers is by graft copolymerization. Through the grafting desirable properties can be introduced to the polymers without altering their bulk properties. The degree of the modification can be controlled by changing the grafting conditions.

This abstract summarizes our work on modification of OPEFB fiber by grafting methyl methacrylate (MMA), acryl amide (AAm) and butyl acrylate (BA) using hydrogen peroxide as an initiator. The grafted products were characterized by gravimetric analysis, FTIR spectroscopy and scanning electron microscopy to confirm and determine the extent of the grafting .

Experimental

Materials

OPEFB fiber was obtained from Sabutek Sdn. Bhd., Malaysia. It was ground to 100 μm-250 μm, washed with hot water and acetone, and dried in an oven at 60°C to constant weight. MMA and BA of more than 99% purity were purchased from Fluka Chemie, Switzerland and purified by passing through a column packed with an activated alumina to remove the inhibitor. Analytical grade of AAm(99%) was obtained from Fisher Chemical and used as received. Analytical grade hydrogen peroxide was purchased from Riedel-de Haen, Germany and ammonium ferrous sulfate, (analytical grade reagent) was obtained from BDH, United Kingdom.

Graft coplymerization of OPFEB fiber by vinyl monomers

All the graft copolymerization reactions were carried out in a 250 mL three-neck flask equipped with a nitrogen gas inlet, stirrer and condenser, and placed in a thermostat water bath. The grafting process was carried out as follows: 1.00 g OPEFB fiber, 100 mL of distilled water and a chosen amount of 1.0 M nitric acid were first introduced into the flask and stirred for 30 min. The required volume of 2.0 M H_2O_2 and amount of ammonium ferrous sulfate were then added into the flask and allowed to react with the fiber for 5 min. The polymerization was initiated by adding the required amount of the monomer at a chosen temperature and allowed to propagate for a selected reaction period. The reaction flask was then cooled to the room temperature and the crude product was collected by filtration and purified by soaking or Soxhlet extraction using a suitable solvent, dried in an oven at 60°C to constant weight.

Product characterization

The percentage of grafting was calculated by the following formula:

$$\text{Percentage grafting } (P_g) = \frac{(W_2 - W_1) \times 100}{W_1}$$

where, W_1 is the weight of original OPEFP and W_2 is the weight of the purified grafted product. The presence of functional groups were determined by Fourier transform-IR spectroscopy using KBr disk technique and the surface morphology was studied by scanning electron microscopy.

Results and discussion

Hydroxyl radicals produced by the redox reaction of H_2O_2 and Fe^{2+} ions create active center on the cellulosic fiber by abstracting hydrogen atoms from it. These macroradicals then react with the added vinyl monomer to form polymer chains attached to the fiber. The presence of the hydroxyl radicals depends on reaction parameters such as reaction temperature and period as well as the concentrations of the initiator, co-catalyst and monomer. The results also indicate that the percentage of the grafting increases with the type of the monomer used. The maximum percentage of grafting (265%) for BA was obtained when 5.0 mL this monomer was copolymerized under the following conditions: reaction period: 120 min, reaction temperature: 55 °C, and the amount of H_2O_2: 5.88 mmol. For MMA, the maximum percentage of grafting (220%) was recorded when the copolymerization was carried out at 50°C for 120 min in the presence of 3.92 mmol of the initiator. In order to graft AAm onto the OPEFB fiber , a comonomer (methyl acrylate(MA)) is needed. The maximum percentage of grafting (232%) was obtained when the reaction was carried out using 11mmol of MA and 25. 6 mmol AAm for 90 min at 50°C. The amount of H_2O_2 used for this copolymeization was 3.98 mmol.

The presence of polyBA, polyPAAm and polyMMA on the OPEFB were verified by the FTIR spectra and SEM micrographs of OPEFB and OPEFB-g-polyMMA, OPEFB-g-polyPAAm and OPEFB-g-polyBA as shown in Figures 1 and 2 respectively. The characteristic peaks of C=O (1730 cm^{-1}) which correspond to the stretching of the carbonyl group in the ester of polyBA and polyMMA are observed in OPEFB-g-polyBA and OPEFB-g-polyMMA. The presence of peaks around 1663 cm^{-1} which correspond to C=O stretching of an amide OPEFB-g-polyPAAm shows the presence of PAAm.

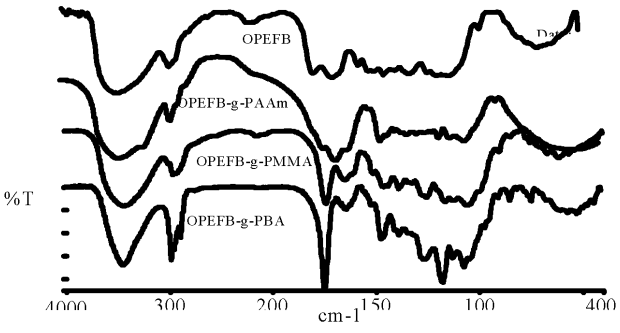

Figure 1: FTIR spectra of the OPEFB and grafted products

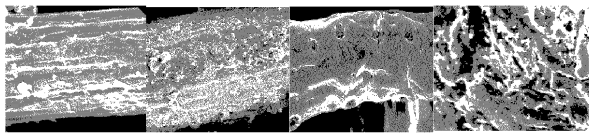

Figure 2: SEM micrographs OPEFB, and grafted products

OPEFB OPEFB-g-PBA OPEFB-g-PMMA OPEFB-PAAm

The surface of OPEFB is rough with groove-like structures as shown in Figure 2. The rough surface may be caused by the removal of intercellular binding material. After the grafting process, the surface of the fibers is covered by the polymers which are strongly attached onto the fiber surface as they are chemically bonded.

Conclusions

Copolymerization of several vinyl monomers ((MMA, BA and AAm) onto oil palm empty fruit bunch fiber (OPEFB) by using hydrogen peroxide (H_2O_2/Fe^{2+}) as an initiator has been successfully carried out. The grafting percentages depend on the concentrations of the initiator and monomer as well as reaction period and temperature. The FTIR spectroscopic data and the SEM micrograph of purified products confirmed the presence of these synthetic polymers on the OPEFB fiber.

References

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