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Biodegradability Assessment of Bio- flocculant via Anaerobic and Aerobic Test

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***Abstract*—The study evaluated the biodegradable ability of bio-flocculant that is a bio-polymer extracted from a citrus peel waste. This citrus peel waste so call a household waste which was generated in abundance from one of the Universiti Sains Malaysia cafeteria. Cellulose and Oak were used as a reference and blank sample respectively as comparison. Two difference analysis was conducted which is anaerobic (Oxitop) and aerobic (Sapromat). The finding reveals that both analyses are applicable for bio-polymer except for Oak that depicted no sign of degradation under anaerobic condition.**

Keywords-Biodegradability, bio-polymer, Oak, citrus peel waste, Oxitop, Sapromat

I. INTRODUCTION

Recently in few years back, many research attempts to propose the biodegradable materials for commercial production to be utilize in various sectors. One challenge of this claimable biodegradable material is to minimize the environmental effect through its biodegradability ability. Various existences of suitable methods for the evaluation of the environmental safe use and disposal including basic biodegradation tests, eco-toxicity tests and general guidelines for the different applications has been practice but still the finding is a lot more to explore.

Degradation is a basic characteristic of polymers and plastics. It is based on the fact that most of these materials are in fact organic compounds that can undergo physical oxidation, as well as mechanically and chemically induced degradation. Degradation was generally a process that was to be reduced and eventually avoided in order to guarantee for durability and long service life span of plastics and polymer [1]. This is the perception and the principle in their earlier development.

Although many by-products in agricultural industries are natural, their use or disposal has challenged society. A number of by-products and co-products of agricultural businesses are presently returned to the land as fertilizers or soil modifiers, fed to animals or fish as nutrients, burnt for energy, or applied to value-added conversions such as plastic body for car was that was studied as early as in year 1941 [2]. With the dramatic increase in biotechnological activity comes a concomitant responsibility to increase the capacity and sophistication of waste management systems [3].

Generally the degradation of plastic materials in the environment can be categorized in two parts. First part through the disintegrations process which involved a modifications in physical (dimensional change, weight loss, viscosity change), chemical (broken bonds, MW reduction), and mechanical properties and decrease in strength, flexibility, increase in brittleness) that related to light, stress, heat, microorganisms, hydrolysis and oxidation factors. Second parts will engaged mineralization where digestion of plastic fragments resulting in ultimate generation of CO_2 + H_2O + bio-compatible products [1].

There fore the proposed study aim to evaluate the degradability of the extracted bio-polymer from the domestic waste via anaerobic and aerobic test method.

II. MATERIAL AND METHODS

A. Preparation of the Anaerobic Oxitop Test Medium

Medium for Oxitop was prepared according to anaerobic biodegradation method described according to ISO 14853 (2005-02-01) [4].

B. Aerobic methods (Respirometer test)

1) Materials:

Bio-flocculant < 0.25 mm
Oak powder < 0.25 mm
Crystalline cellulose

2) Preparation of inoculum:

The inoculum was preconditioned to reach the endogenous respiration rate, by washing once with tap water, diluting to a concentration of 3 g L^{-1} dry matter and finally aerating for 2 days [5]. This starved activated sludge suspension was further diluted to the inoculum concentration given in OECD protocol [6]. For this experiment some modification was done in the preparation of the inoculums as described below.

The inoculum's solution was obtained from the bio-waste compost extraction. Certain amount of the bio-waste compost was diluted up to 1 L with tap water, shake vigorously and leave it settle for a minimum 1 hour. The above step was repeated for another three bio-waste compost extraction.

a) Inoculated medium

Chemicals: 1.25 g Urea, 1.25 g $Na_2HPO_4.12H_2O$.

The inoculated medium was prepared by diluting 100 mL of extracted inoculum solution to 1 litre (together with mineral salts medium; 1.25 g urea and 1.25 g $Na_2HPO_4.12H_2O$).

3) Respirometer flask

Blank test (inoculated medium solution), reference test (crystalline cellulose powder) and sample test (Oak and Bio-polymer) was prepared in the 500 mL respirometric flask. Each flask was contained 0.25 g ($\leq$ 1 gL^{-1}) testing material except blank test. Each flask was filling up to 250 mL and prepared in duplicate.

III. RESULTS AND DISCUSSION

Generally, biodegradability testing monitors the degree of activity of microorganisms exposed to a material that is being tested for a biodegradable status. In the test, if the microorganisms recognize the material as a food source, then an increase in biological activity is observed through data collection specifically designed to assess biological conversion of organic carbon to inorganic carbon. If the material is not a recognizable food source or is toxic or inhibitory, then there is no measurable increase in biological activity or, in some cases, there is a marked decrease in activity relative to a biodegradable control. Since chemical may be degraded by only a specialized, small fraction of the microbial population, the low level of biomass used in ready biodegradability test (RBT) make them very dependent on the origin and the composition of the inoculums [7,8]. The results below illustrated the biodegradable ability for cellulose, oak and bio-polymer in the two different conditions (aerobic and anaerobic).

A. Biodegradation measurement via anaerobic (Oxitop) test method

The measurement of the samples was carried out according to International Standard ISO 14853(method by measurement of biogas production) [9]. Based on the testing conducted in accordance with the specified method above, test material cellulose and bio-polymer (BP) achieved 56.7% and 45% biodegradation respectively within 33 days (Fig. 3.5 and Fig. 3.6) except oak sample which depicted without any degradation process as illustrated in Fig. 3.7. The biodegradation percentage was believed to increase for cellulose and bio-polymer as the experimental period was not yet completed that is 60 days as to indicate the ultimate anaerobic biodegradation.

The pressure generated by each sample in the anaerobic Oxitop flask was depicted as in Figs. 3.1, 3.2 and 3.3). Cellulose was selected as reference test material as it is known to have a 100 percent biodegradable ability. Any how the blank sample (inoculums) where the source sample was from the anaerobic digester at ISWA was generating a double pressure (300 hPa) compare to previous experiment (150 hPa) even though the sludge sample was taken from the same sampling point. The variation in the pressure for inoculums probably due to new incoming organic compound that enter the treatment system or else by the lack of skill in carried out the experiment which is the human error could also influence the results finding.

These result revealed that a great care should be taken in determining the organic content of the inoculums as described in the ISO 14853 and in addition the test method should be frequently perform so that the experimental skill shall be maintained.

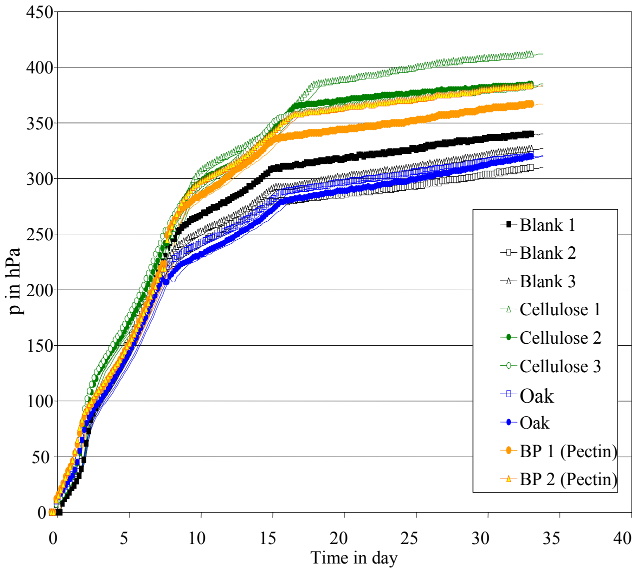

Fig. 3.1 Pressure generated in Oxitop flask by each sample

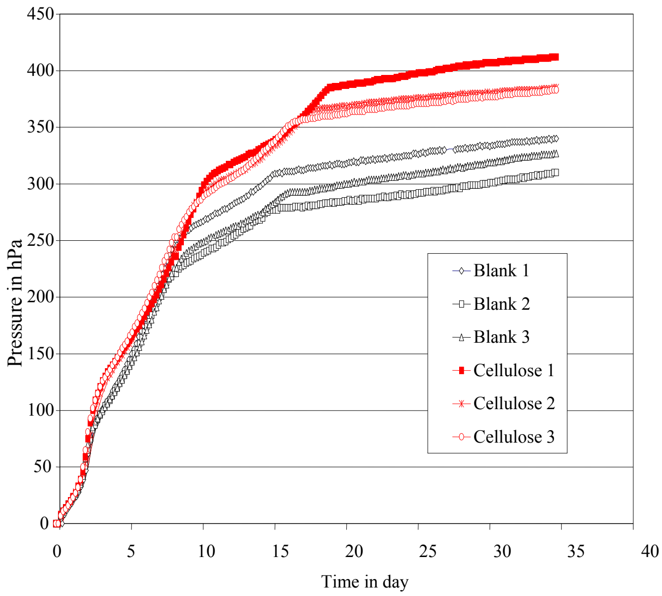

Fig. 3.2 Pressure generated by Blank sample (inoculum) and Reference sample (cellulose)

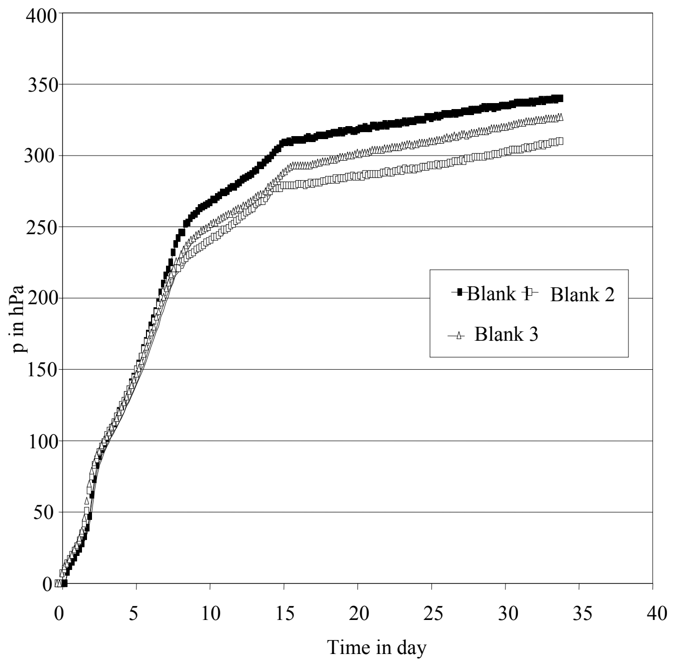

Fig. 3.3 Pressure generated by Blank sample (inoculums)

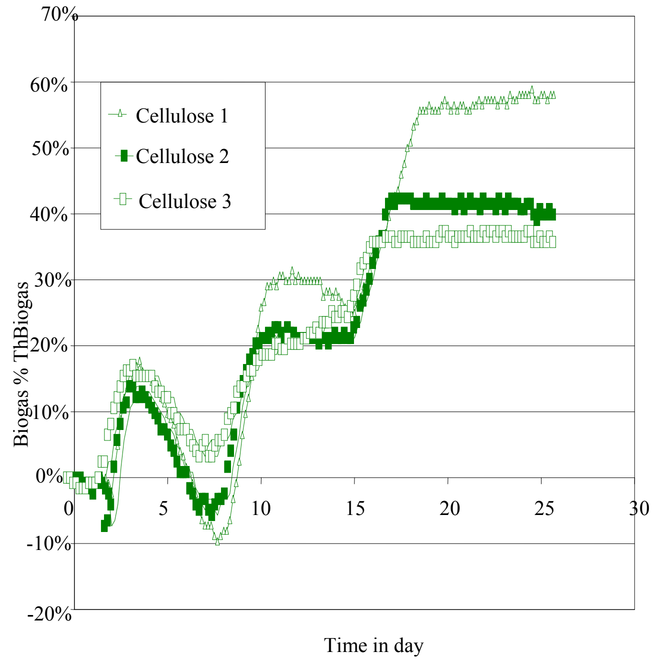

Fig. 3.5 Biogas produced by reference sample (cellulose) in comparison to Theoretical biogas

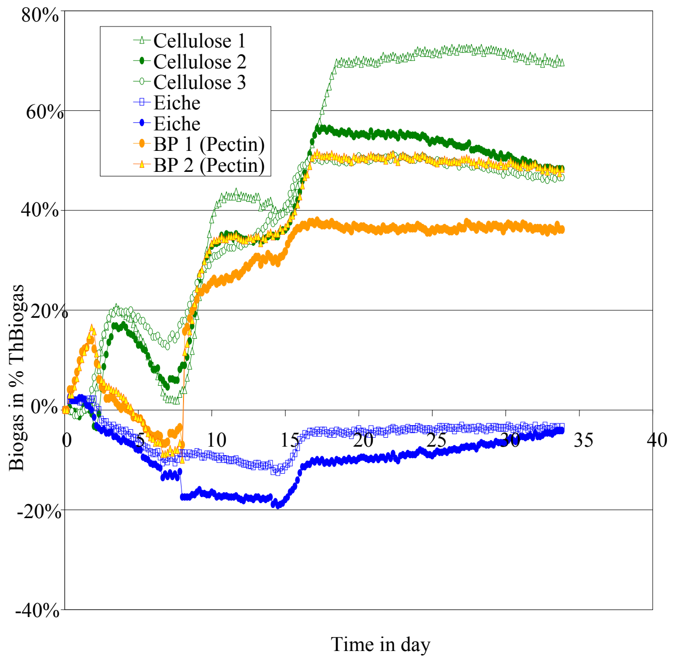

Fig. 3.4 Percentage of Biogas produced in comparison to Theoretical Biogas

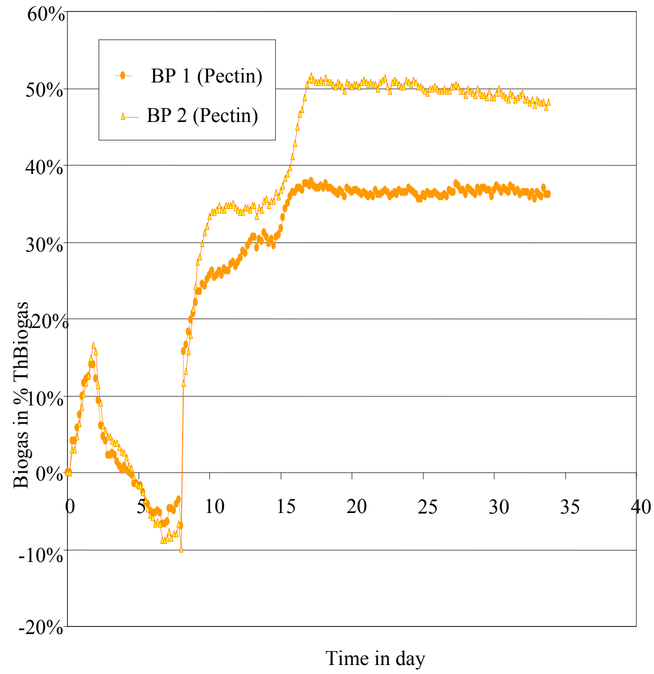

Fig. 3.6 Percentage of biogas produced by Bio-polymer sample in comparison to Theoretical biogas

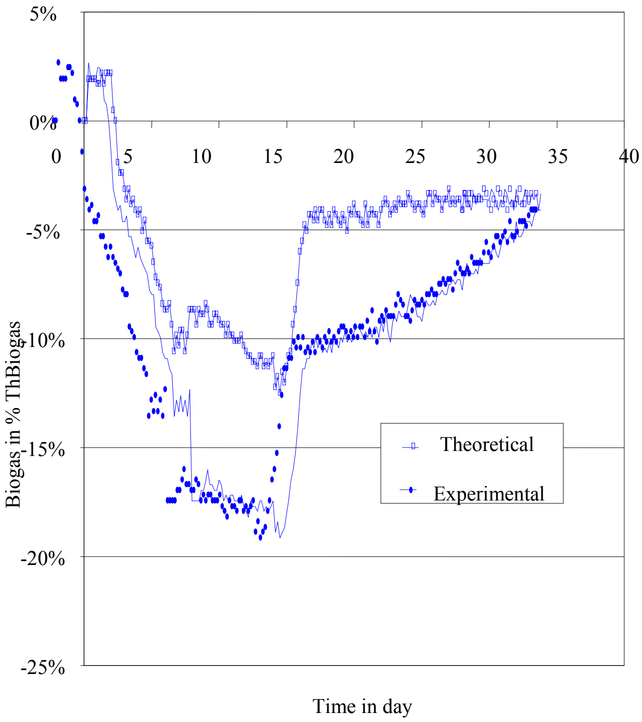

Fig. 3.7 Percentage of biogas produced by Oak sample in comparison to Theoretical biogas

B. Biodegradation measurement via sapromat (aerobic) test method

The divergence between Oxitop and Sapromat methods in the Respirometric test (aerobic or anaerobic process) is the way that the biodegradation is calculated. Biodegradation is calculated from the measured BOD for the Oxitop method and the ThOD as in the Sapromat. The major difference between the two respirometers (Oxitop and Sapromat) is the supply of oxygen but also the different in the degradation processes by other microorganisms involved and etc. The Sapromat is able to replace the oxygen which has been used for biodegradation from the electrochemical oxygen production unit. Due to the construction of the test system this replenishing process only occurs if a certain subpressure is reached. In the Oxitop such a replacement of oxygen is not necessary, but care has to be taken that the headspace over the liquid phase in the test vessels is large enough, so that it contains sufficient oxygen and enables complete oxidative biodegradation of the organic test compound [4].

Figs. 3.8 and 3.9 illustrated the amount of the oxygen consumed by microorganisms to biodegrade the bio-polymer and oak sample. It revealed that bio-polymer (BP) consumed 548 mgO_2/0.25 g sample and 124.5 mgO_2/0.25 g samples for oak within 43 days and 51 days respectively (Fig. 3.8 and Fig. 3.9) about 400 times faster than Oak. The utilization of a low initial substrate to initial biomass ratio in biodegradability tests leads to a better mineralization of the substance associated with a diminution in cellular growth [10].

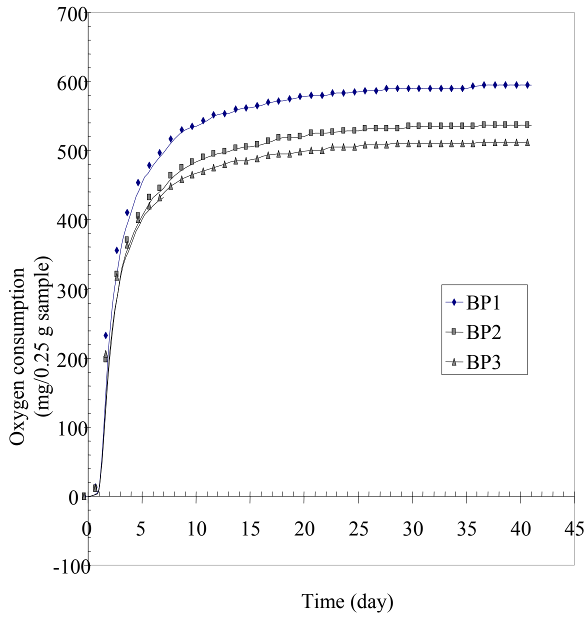

Fig. 3.8 Oxygen consumption by microorganisms to degrade the bio-polymer sample in the biodegradation process

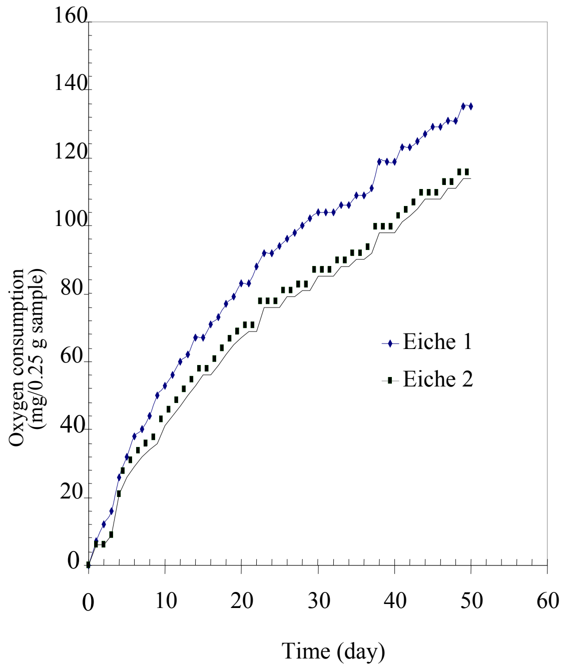

Fig. 3.9 Oxygen consumption by microorganisms to degrade the Oak sample in the biodegradation process

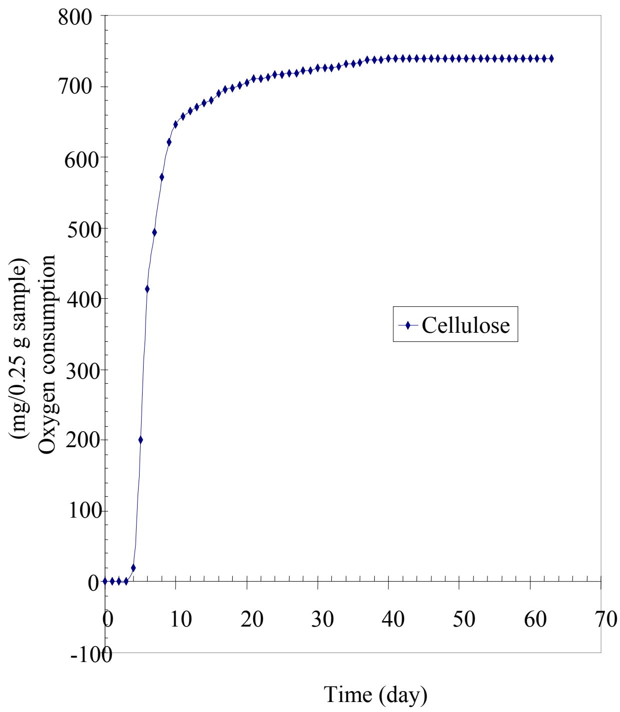

Fig. 3.10 Oxygen consumption by micro organisms to degrade the reference sample (cellulose) in the biodegradation process

IV. CONCLUSIONS

Cellulose as reference sample illustrates a good response in both test method as well as for biopolymer. In contrary Oak was proven not to have any degradation in an anaerobic condition within this experimental anaerobic condition to indicate a readily biodegradable material.

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