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Research Article

USE OF POLYSTYRENE-POLY(3-HYDROXYBUTYRATE) BIOBLENDS AS A COATING MATERIALS OF NITROGEN-PHOSPHORUS GRANULES AND ITS CHARACTERIZATION

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ABSTRACT

Nitrogen-phosphorus (NP), the very soluble fertilizers, is easy to wash-out in the soil. Objectives of the research were to produce a slow release fertilizer (SRF) using polystyrene (PS)-Poly(3-hydroxybutyrate)[(P(3-HB)] bioblend as the coating materials, and its characterizations. The possibilities of chemical interactions and surface morphology of coated NP granules were observed using FTIR Spectrophotometer and Scanning Electron Microscope, respectively. phosphorus released from coating granules measured by Uv-Vis Spectrophotometer. Results showed that the IR spectra of uncoated and coated NP granules showed that no chemical interactions were observed during the coating process. The characteristic test using SEM showed a clearly the core of the NP granules coated by the polymer. The percentage of phosphorus released after 48 hours from uncoated, coated granules of Formula 1, 2 and 3 were 68.44, 48.03, 26.90%, and 23.37%, respectively.

Keywords: slow release, bioblend, nitrogen-phosphorus, coating.

INTRODUCTION

Slow release is a dosage form designed to minimize the release of the drug into the medium slowly or gradually. The release of the substances, usually pharmacological active ingredients, can be much longer and extend the effect of the drug[1,2,3]. The use of slow release or controlled release formulation technology is not only used for drugs but can also be used for pesticides, fertilizers or other substances to reduce the cost of active ingredients [4,5,6].

Slow release fertilizers contain nutrients that delaying availability for plant absorption. The principle of slow release-fertilizer is the reducing of nutrient release from fertilizers to protect from conventionally fast dissolved fertilizers by coating protection from semi-permeable materials, insoluble in water or permeable porous material[7,8]. The controlling includes the rate of the water penetration, the dissolve, and the release of fertilizer in suitable amount and release rate to fulfill the need of plants[9,10]. The objectives of slow-release fertilizers application are to improve the efficiency of nutrientsabsorbed by plants and reduce the loss of its that can minimize environmental pollution[1,10].

The release process of nutrients from its polymer coated occurs in three stages. At the first step, water molecules will penetrate through the polymer layer continued by the second step, the water will dissolve the nutrients in the core and cause an inner pressure. The coating layer will swell and enlarges of the pore for diffusion. At the third step, nutrients will be released through the pore and driven by a concentration gradient in the layer, and/or through mass flow driven by a pressure gradient [11,12].

Polystyrene known as styrofoam is a cheap synthetic polymer, widely used, especially as an insulator and an electronic wrapper. It has not biodegradable characteristic. Related to this nature, anenvironmental problem will have occurred. For this reason, a mixture of polymers consisting of at least one biodegradable polymer or biopolymer with another non-degradable polymer one called bioblend is required [14,15].

P(3-HB) is a biopolymer produced by bacteria such as *Ralstonia eutropha* and *Erwina* sp. USMI-20[16]. This biopolymer has biodegradable and non-toxic properties. Using the biopolymer because expected to obtain the slow released NP and no toxic effect on the soil microorganisms [17].

In previous studies, it has been reported that the use of PS-Starch and PS-Polycaprolactone bioblend on urea coated can prolong its release[18].Therefore, in this study, researchers wanted to evaluate the effect of bioblend using inexpensive and environmentally friendly coating materials with a variety of formulas of PS-P(3HB) on the release rate of active substances fromcoated NP granules.

MATERIALS AND METHODS

Materials used were P(3HB) (Aldrich Chem Co), PS, NP granules (Wasps), chloroform (Merck), potassium dihydrogen phosphate (Merck), potassium antimonyl tartrate (Merck), ascorbic acid (Merck), ammonium heptamolybdate tetrahydrate(Merck), sulfuric acid (Smart Lab), distilled water (PT. Bratachem).

Preparation of Coating Solutions

One and half grams of PS was mixed with 0.5 grams of P(3HB) for PS-P(3HB) bioblend at a ratio of 3:1. The mixture was dissolved in 50 mL of chloroform. The solution is stirred using a magnetic stirrer at a rate of 380 rpm for 10 minutes.

Coating Process

The coating was created using a spray dried coating method. The uncoated NP granuleswas sprayed with the coating solution made previously above. 25 grams of NP granuleswas placed into a coating pan. The coating solution was loaded in a solution container. The uncoated NP granuleswas sprayed with a coating solution. The coating pans was rotated at an adjusted rate, and the temperature was set at 60-70. The NP granules were dried using an oven at the temperature of 70-80 for 1 hour to ensure the solvent was evaporated completely.

Morphological Surface Characteristics of Granulesbya Scanning Electron Microscope

The morphological surface characteristics of granules were doneto observe the properties and compatibility of polymer coating with NP granules. The evaluation was performed by a Scanning Electron Microscope (SEM JEOL-JSM-6510LV).

Fourier Transform Infrared Spectroscopy (FTIR) Test

The evaluation was conducted to determine the possible interactions between the components of the coating materials with NP granules. The analysis was carried out using a FTIR Spectrophotometer, Universal ATR type PerkinElmer.

Phosphorus Release Test

A half grams of the coated NP fertilizers produced previously wasplaced into a container containing 100 mL of distilled water at a temperature of 25-30. Five mL of releasing medium was withdrawn from the container at predetermined times. In order to maintain the sink condition, the fresh medium at the same volume and temperature was added to the container. Three mL of filtered releasing medium was mixed with 3 mL of dye reagent. The transparent solution will changes into blue color solution once the 2 solutions were mixed. Absorbances of the final solutions were measured by a UV-Vis spectrophotometer at a wavelength of 713 nm. The concentrations of sample solutions were computed using standard curve regression equation.

RESULTS AND DISCUSSION

The profile of NP granules of uncoated NP granules; coated NP granules of Formula 1, 2 and 3 shown in Figure 1. The coating process and materials greatly influence the morphology and release profile of the active substances. The coated granules look shiny because of the polymer layer used as a coating. The use of PS in this experiment is in an effort to use plastic waste in the form of styrofoam which is difficult to decompose in the environment[12]. Therefore, in this study we added an easily biodegradable polymer known to be produced by certain bacteria. In theory, this biopolymer will form small pores when it comes in contact with water and due to decomposition by bacteria in the soil or the environment. So, it is through this formed axis that the active substance of NP fertilizer comes out slowly and the absorption by roots is more efficient because NP substances are not released in large quantities in a short time[4,6].

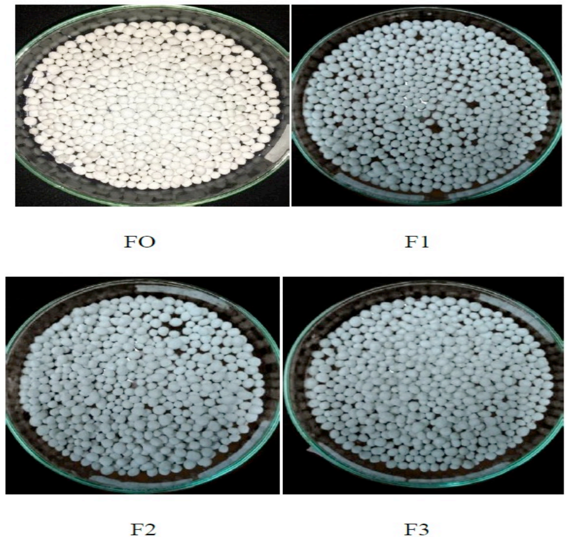

Figure 1: Profile of uncoated NP granules fertilizers (F0) and coated granules formula F1, F2, and F3.

SEM micrographs of uncoated NP granules; coated NP granules of Formula 1, 2 and 3 shown in Figure 2. There was a clear difference between coating polymers and granules core. The outer layer was a PS-P(3-HB) coating polymer that can reduce the rate of water molecules diffusion into the core, and the diffusion of nutrients out from the core and middle layer of NP granules as well[2,5].

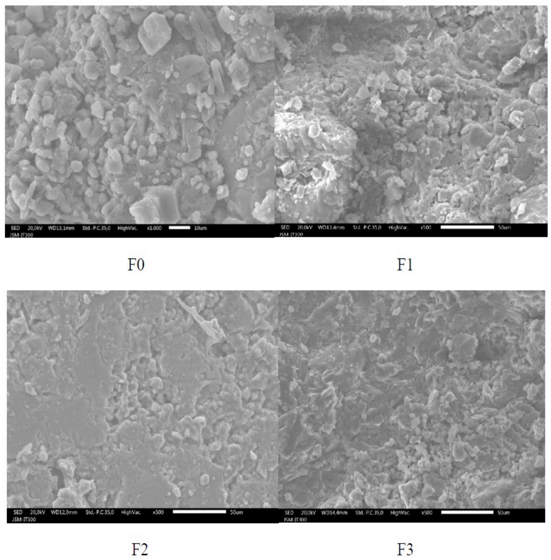

Figure 2: Scanning Electron Micrograph (SEM) of uncoated; coated NP fertilizers granules Formula F1 [PS:P(3-HB)-3:1], F2 [PS:P3HB-4:1], and F3 [PS:P(3-HB)-5:1] were depicted in SEM observed at 1000 × magnification.

As shown in Figure 3, the FTIR spectra of uncoated NP granules showed similarity with coated NP granules of Formula F1, F2, and F3, although there was a slight shift in the wave number still in the range. For Formula 3 [PS:P(3-HB)]at a ratio of 5:1 showed very similar FTIR spectra with uncoated NP fertilizers granules. On Figure 2. F0 and F1. four peaks that identified the same cluster. The peaks of 3024 cm^{-1} and 3014 cm^{-1} granule of NP and F3 fertilizers are C-H aromatic tensile vibrations. The peak of 1406 cm^{-1} and 1404 cm^{-1} in NP and F3 fertilizer granules was a bending vibration of the C-H alkane group[3,4]. The peaks of 1048 cm^{-1} and 1053 cm^{-1} granule of NP and F3 fertilizers were bending vibrations of the C-O group. The peak of 620 cm^{-1} and 693 cm^{-1}

in the NP and F3 fertilizer granules were C-H bending vibrations. Uncoated NP fertilizers and polymer coated granules used were compatible, there were no chemical interactions observed, but only physical interactions occur and indicate no new cluster formation[22].

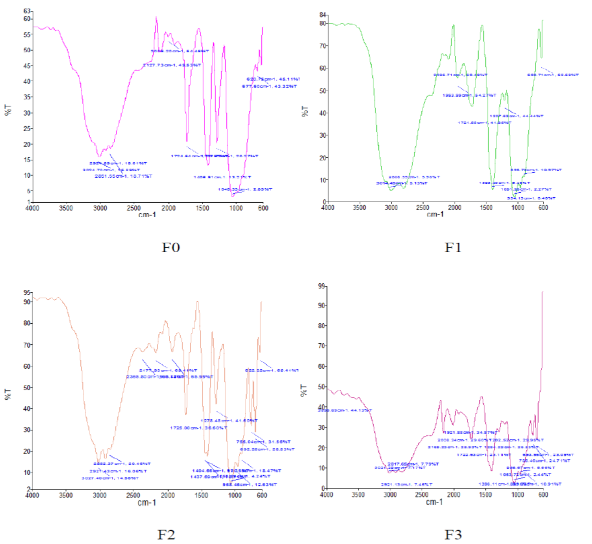

Figure 3: FTIR spectra of uncoated NP fertilizer granules (F0); (F1), (F2), and (F3) werethe FTIR spectra of coated granules of Formula 1, 2, and 3, respectively. Formula 1, 2, and 3 contain [PS:P(3-HB)] at the ratio of 3:1, 4:1, and 5:1, respectively.

Phosphorus was released slowly from coated NP fertilizers granulesper unit time in distilled water media as shown in Figure 4. The percentage of phosphorus released from uncoated NP fertilizer granules after 48 hours was 68.44%. While from Formula 1, 2, and 3coated NP fertilizer granules after 48 hours were 48.03, 26.90, and 23.37%, respectively. It was assumed that the mechanism of phosphorus released from coated NP fertilizers granules occurs in three steps i.e penetration of water molecules into the pores of the layer, dissolution of fertilizer, and solutes will spread out through the layers. In this case, diffusion is controlled by differences in concentration through the layer.

The release kinetics profile of phosphorus from uncoated NP granules followed Korsmeyer-Peppas release kinetic model (r=0.804) [19,20]. While from coated NP granules of Formula 1, 2, and 3 followed the Higuchi release kinetic model with the regression (r) were 0.945, 0.820, 0.818, respectively[21]. The release mechanism ofphosphorusous from coated NP fertilizer granules was assumed by a diffusion process based on Fick's law equation.

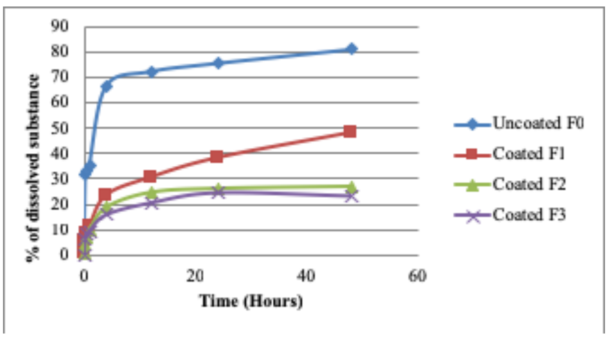

Figure 4: Percentage of P_2O_5 released from uncoated NP fertilizer granules (F0) and coated NP granules of Formula F1, F2, and F3.

In this paper we have just reported the process of formulation and characterization of NP fertilizer products overlaid using PS-P (3-HB) bioblend. This research is still continuing in the future, including efforts to find biopolymers other than P (3-HB) as forming bioblend with PS synthetic polymers. P(3-HB) is currently still produced in limited ways using fermentation techniques, so the price is still relatively high. In an effort to reduce the production costs of slow release fertilizers in the future, we use natural carbohydrates, for example from the starch group.

CONCLUSION

Results showed that PS-P3(HB) bioblend as polymer coating for NP fertilizers granulesby spray dried coating technique could be implemented in the production of slow release NP fertilizer granules off slowly. The coating process and materials greatly influence the morphology and release profile of the active substances. The release profile of coated NP fertilizer granules using the PS-P3(HB) bioblend has characteristics as a slow release. the release rate is slower than NP fertilizer granules without coating. The double coating NP granules were more effective and efficient compared to conventional one.

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