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Effect of Zeolite-Chitosan Composites Coating on Urea Fertilizer as Slow Release Fertilizer.

Dina Kartika Maharani*, and Arif Novan.

Department of Chemistry, Faculty Mathematic and Natural Sciences, Universitas Negeri Surabaya, Jl. Ketintang Surabaya Indonesia (60231).

ABSTRACT

In this research, urea fertilizer were coated by zeolite-chitosan composites as slow release fertilizer. Zeolit-chitosan composites were prepared by mixing natural zeolit and chitosan solution and then impregnated into urea fertilizer with ratio urea : zeolit-chitosan = 70 : 30 to obtain urea slow release fertilizer. Characterization of urea slow release fertilizer were done both physically and chemically including functional group analysis and morphology analysis using Fourir Transform Infra Red and Scanning Electron Microscopy instruments. Slow release urea fertilizer coated by zeolit-chitosan were evaluated and observed by percentage of nitrogen release from urea using elemental analysis method. The result show that greater the concentration of zeolite in the matrix of zeolit-chitosan urea slow release fertilizer, the lower the percentage of nitrogen release from urea fertilizer. The percentage of nitrogen release for 7 days for urea coated zeolit-chitosan composites was 2.5 % and stay constantly up to 35 days. It indicate that zeolit-chitosan composites are potential to decrease nitrogen release from urea fertilizer to be functioned as slow release urea fertilizer.

Keywords: Urea, zeolite, chitosan, slow release fertilizer

**Corresponding author*

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INTRODUCTION

The growth of population nowaday, result in the increasing of agriculture products demand quantity. Therefore, the consumption of fertilizers also rise significantly in quatity in order to fullfil agriculture product demand. Urea fertilizer is one of major fertilizer used by people due to its highest essential element content namely Nitrogen (N) which is useful for plants growth. The function of N for plants are to encourage the growth of leaves as well as forms of protein and chlorophyll. Nitrogen is also very important because it is the main constituent of proteins and some biological molecules [1].

The study of nitrogen usage in plants reported that only about 40-70% of the nitrogen in the fertilizer, can be absorbed by plants. This is because soil and plants compete in absorbing nutrients present in the fertilizer [2]. In addition, nitrogen is easily loss into air in the form of ammonia gas (NH_3) and loss as nitric (NO_3^-) form when fertilizer is soluble in water [3], so that they contribute to environment issue which also related to health issue directly or indirectly [4]. To overcome these problems, the nitrogen uptake can be designed by slowing release of nutrients in fertilizer, this method is also called slow release fertilizer (SRF)[5]. The European Standardization Committee (CEN) states that fertilizer that can be said of SRF fertilizer is a fertilizer that is able to release nutrients more slowly than convensional fertilizer [6]. This gradual release of nutrient promotes the fast growth of plants because of high delivery nutrients to the plants [3].

Slow release function on fertilizer to regulate nutrients release in slowly rate into environment can be obtained through utilization of inorganic material or composites material. Preparation of SRF by adding or coating material into fertilizer can enlarge the size of fertilizer, increase the hardness of fertilizer, and control amount of nutrient release. Zeolit is inorganic crystalline material contain aluminosilicate framework with high cation exchange properties which can be served as binder, absorbent and ion exchanger [7]. The zeolite frame structure is composed of tetrahedral units $(AlO_4)^{-5}$ and $(SiO_4)^{-4}$ bonded together through the oxygen atoms forming the pores of the zeolite. Coating of zeolit to urea fertilizer as SRF has gained more attention today, due to several advantages of zeolit which can deliver fertilizer to plants at slow rate and improve soil condition through enhancing nutrients efficacy and minimize ammonia volatilization [8].

To improve the efficiency of nitrogen release from soil, natural polymers such as starch, chitosan and cellulose also can act as carrier for nutrient in which active ingredient is entrapped, encapsulated or absorbed [3]. Chitosan is one of natural polysaccharide that produced by deacetylation of chitin, has a structural unit polymer compound of glucosamine in beta bond 1,4 or polymer of 2-amino^{-2-}deoxy-D-glucose. Chitosan is also a cationic polymer that can interact with polymers and / or negatively charged molecules [5]. The amino group of chitosan can be interacted with nutrients in fertilizer, so that in this way, the amide linkage can control the release of nutrient in fertilizer for rapid degradation and running-off [9]. Chitosan also has good stability when it interacted with inorganic support or other organic polymer [10]. Based on the physical and chemical properties of the zeolite and chitosan, it is potential to developed urea SRF based on zeolit-chitosan composite. The current research was aimed to prepared urea SRF by adding zeolit-chitosan composites into urea fertilizer and study the effect of zeolit composition on nitrogen release in soil.

MATERIALS AND METHODS

Zeolit-chitosan composites were prepared from natural zeolit and chitosan of 85% degree of deacetylation obtained from shrimp shell isolation. All chemicals used were analytical grade from Merck.chem.co. Urea fertilizer was purchased from Petrokimia.co.ltd.

Preparation Zeolit-Chitosan Composites

Zeolit-chitosan composites were prepared by mixing natural zeolit powder of composition 3% and 5% and 1% chitosan solution in acetic acid with volume ratio 1 : 1 then stirred with magnetic stirrer for 24 hours at 40^{o}C.

Coating of Urea Fertilizer With Zeolit-Chitosan Composites

To make urea SRF, the urea fertilizer was mixed with zeolit-chitosan solution with volume ratio 7: 3, then stirred with magnetic stirrer for 1 hour and then dried in oven at 50 ^{o}C until constant weight [5]. The

Characterization of Urea SRF were done both physically and chemically includes functional groups analysis using FTIR instrument and morphology analysis usingSEM instrument.

Study of Nitrogen Release from Urea SRF

The release study of total inorganic Nitrogen from urea was carried out using soil taken from the surface layer 0-20cm depth. The soil were incubated with 180mL water for 0,7,14,21,28 and 35 days. 50 mL water were tapped weekly and analysed with elemental method.

RESULTS AND DISCUSSION

Characterization of Urea SRF

Chemical characteristics of urea SRF can be known with FTIR characterization which aims to know the functional group of SRF urea fertilizer. The characterization was performed in Chemical Laboratory of ITS using FTIR-8400S SHIMADZU instrument.

Based on the FTIR spectra in Fig.1, the presence of zeolit functional group SiOH groups is shown at wave number 2471.04 cm^{-1}. An absorption band at wave number 1158.26 cm^{-1} indicates the presence of Al-O stretching vibration, bending vibration of Si-O is shown at the top of the wave number 571.69 $cm^{-1.}$ CN-shifted absorption band peak of the wave number 1450.52 cm^{-1} to 1457.5 cm^{-1} that indicates an interaction between urea with chitosan and zeolite-chitosan, while the shift in the peak of the wave number of amide from 1642.5 cm^{-1} to 1634.5 cm^{-1} indicates -NH interaction from the chitosan and zeolit. This result was in accordance with previous research carried out by Chen, et al which showed that the amide-shifted peak indicate encapsulation urea in zeolit-chitosan matrix. The interaction between chitosan and urea and also between urea and zeolite-chitosan can cause the slow release of nitrogen in UC and UZC fertilizer [11].

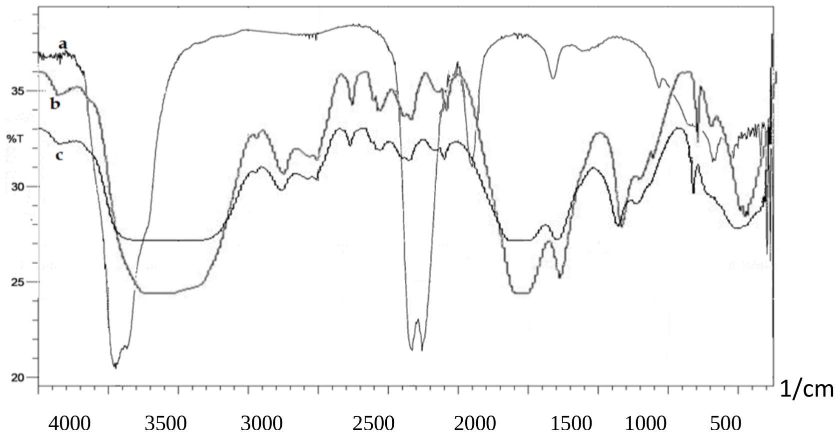

Figure 1. FTIR spectra (a) urea fertilizer (b) urea coated chitosan fertilizer (UC) (c) urea coated zeolite chitosan fertilizer (UZC)

The physical characteristics of urea SRF was known by morphology study of urea, urea coated chitosan and urea coated with zeolit-chitosan composites.

Based on morphology results of fertilizers in Fig. 2, the morphology of UC was more rough than UZC. In general, both UC and UZC shown matrix layer of chitosan and zeolit-chitosan composite on urea surface. It showed that chitosan and zeolit-chitosan composites was succesfully coated the surface of urea fertilizer. Urea fertilizer encapsulated with zeolit-chitosan has a hollow morphology in the presence of valleys and peaks, which indicates that urea trapped and fill the cavities on the surface of zeolit-chitosan [12,13].

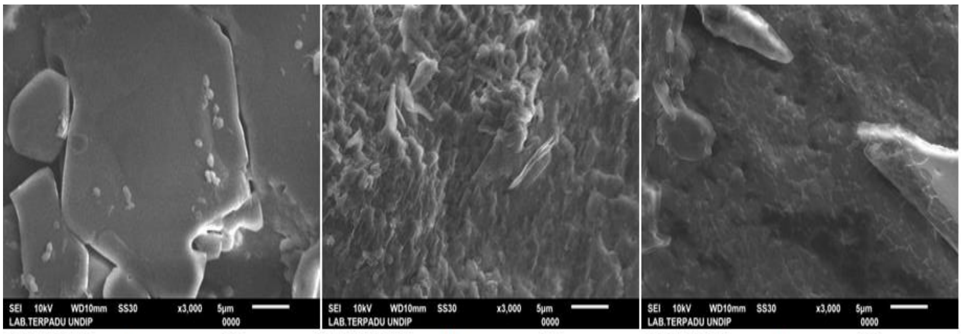

Figure 2. Morphology of (a) Urea fertilizer (b) UC (c) UZC

Study of Nitrogen Release

The amount of total inorganic Nitrogen of urea coated zeolit-chitosan composites which were analysed using elemental analysis method were shown in Table 1 and the graph of percentage nitrogen release of UC and UZC with zeolit content 3% and 5% was shown in Figure 3.

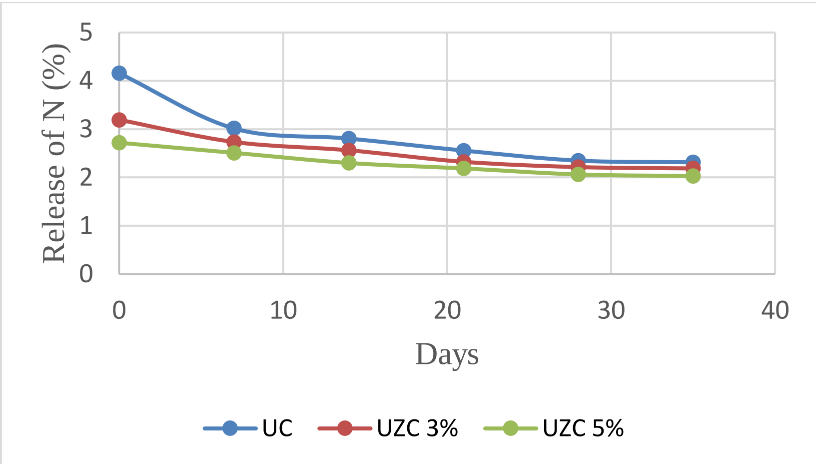

Figure 3. Slow Release Graph of Percentage Release Nitrogen of UC and UZC in 35 days

Table 1. The Percentage of Nitrogen Release in UC and UZC

Day	%N		
	UC	UZC 3%	UZC 5%
0	4.1574	3.1932	2.7186
7	3.0152	2.7343	2.5093
14	2.8055	2.5625	2.2994
21	2.5568	2.3239	2.1869
28	2.3479	2.2143	2.0620
35	2.3149	2.1872	2.0300

Slow release study of nitrogen in urea fertilizer coated with chitosan and zeolit-chitosan composites exhibit the same trend of nitrogen release percentage based on the graph of percentage nitrogen release of

UC, UZC 3% and UZC 5% in Fig. 3. The release of nitrogen in 35 days in UZC was slower than in UC. It means that slow release funcion of zeolit-chitosan matrix on urea higher than chitosan. Chitosan-coated on urea fertilizers can slow the release of nitrogen in which ammonium on urea adsorbed by chitosan causing water retention surface of urea coated chitosan fertilizer [13,14].

Zeolit addition to chitosan as slow release function on urea fertilizer cause interaction between urea with zeolit and chitosan in the zeolit-chitosan matrix resulted in the slower release of nitrogen in urea fertilizer. Based on the data of nitrogen release in UC and UZC, it can analyzed that the increasing percent composition of zeolit in zeolit-chitosan matrix increasing the effectivity of zeolit matrix to give slow release function on urea fertilizer. The percent composition of zeolit 5% in UZC gives the best slow rate of nitrogen release indicated from the regression values of the its`graph closest to 1 which means a stable rate of release. According to international standart of ISO/DIS 18644:2016 for controlled-release fertilizer, the percentage of nitrogen release in SRF are not more than 15% in 7 days. The result of this research was in well accordance with the standart value. This result indicates that zeolit-chitosan composites is potential to be a matrix for SRF.

CONCLUSIONS

Zeolit-chitosan composites can give a slow release function of nitrogen in urea fertilizer. Interaction of zeolit and chitosan through its funtional group effect on the trapped of urea in the core zeolit-chitosan matrix to produce slow rate of nitrogen release. The greater the percentage of zeolit in fertilizer, the slower the percentage of nitrogen release from urea.

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