Nanotechnology Letters

Extended Abstract
Vol. 5, Iss. 1
2020

Advanced Materials Congress 2019: Synthesis of protein rich biomass and organic fertilizer from rice straw and tofu with the aid of Hermetia Illucens - Dr. M. Yusuf Abduh, Institut Teknologi Bandung, Bandung, Indonesia.

M. Yusuf Abduh
Institut Teknologi Bandung, Bandung, Indonesia.

Rice straw is a lignocellulosic biomass produced when harvesting paddy which can be valorized to produce valuable bioproducts. Rice straw can be mixed with tofu residue and used as a substrate for the cultivation of Hermetia illucens to produce protein rich biomass and organic fertilizer. This study investigated potential bioconversion of rice straw and tofu residue using larvae of Hermetia illucenus assisted by microbes to produce protein-rich biomass and organic fertilizer. Larvae of Hermetia illucenus were cultivated in rearing containers (25cm x 20cm) with three different types of feed containing rice straw, tofu residue and solution containing consortium of microbes. The rice straw used in this study contains 22.1% hemicellulose, 30.3% cellulose, 8.0% lignin, and 6.8wt% protein while the tofu residue contains 20.9% protein. The feed rate was set at 150 mg/larva.day and the ratio of rice straw: tofu residue was varied from 1:0 to 1:3. At this condition, the prepupal biomass has a protein content of 31.8 wt% and a fat content of 15.5 %. The cultivation residue contains a relative high amount of organic carbon (43-46%) at pH 7.16-7.82 with a carbon to nitrogen ratio of 22-47 and total macronutrient of 2.33-3.21% and functional microbes of 2.0-4.5 x 108 CFU/m. The results highlight the potential of black soldier fly larvae as a bioconversion agent to convert agricultural waste into protein-rich biomass and organic fertilizer. Proteins exhibit a certain affinity for various iron ions, which play important roles in the living cell. Here, we found that various proteins selectively adsorbed the metal of various precious metals at different pH values. Studies on the sequence of proteins and synthetic peptides revealed that the sequences containing histidine interacted with certain key metal ions (Au3 + and Pd2 +). We then investigated several types of protein-rich biomass as adsorbents of precious metal ions. In the presence of various transition ions, Au3 + and Pd2 + were also selected for adsorption on the tested biomass. Precious iron-bound wires have been rediscovered by aqua regia after charging ironbound biomass. Finally, we have demonstrated the successful recovery of Au3 + and Pd2 + from the metal purification solution and the metal filtration waste using biomass. We propose a systematic approach to recycle the environment from precious metal ions using biomass rich in proteins. Gold and platinum group metals (e.g., Pd, Pt, and Rh) are very important in various industries because of their physical and chemical properties. Since the prices of these precious metals and their mines are limited worldwide, the recovery of precious metals is urgently needed. Strategies for recycling of precious metals from waste are currently hydro or pyro-metallurgical. In the techniques used, adsorption is the most cost-effective and efficient way to recycle precious metal ions. So far, many adsorption materials have been identified; for example, activated carbon, mineral materials, and ion exchange resins. In particular, various types of ion-exchange resins, made from reliable petrochemical polymers, have been developed for various types of iron ions and are widely used in the industry. Over the past decade, carbon dioxide emissions have become one of the world's biggest concerns and petrochemical dependency products have attracted considerable attention. Biomass, such as agricultural products and aquatic resources, does not release additional carbon dioxide when burned. Biomass is therefore expected to be neutral and self-regulating. Many research groups have reported that various types of biomass (e.g., microorganisms, polyphenols, and polysaccharides) catalyze the adsorption of several metal ions in aqueous solution. However, selective recovery of the metal ion deposited from aqueous solution, as well as studying the adsorption method, have been challenging tasks, since biomass is a crude product composed of many different materials. This pulls back and prevents any active demonstration of using biomass for recycling iron from industrial waste containing various iron ions. Protein rich biomass is produced as a natural substitute in the food and agriculture industry, and is usually less expensive (less than 100 US $ / kg). Due to its high protein content (~90%), biomass is an attractive source of peptides and amino acids. Proteins interact with metal ions, and these interactions play an important role in biological processes. There are, however, only limited studies on the interaction between proteins and precious metals. Craig et al. revealed, for the first time, a strong interaction between ovalbumin and Au3 +. In 2000, the formation of the first crystal structure of the Auprotein complex was reported. These reports suggest that proteins are good candidates for the adsorbent of precious metal ions. In the present study, we investigated and revealed strong and selective interactions between purified proteins and precious metal ions. Studies on synthesized peptides identified one of the adsorption sites of the protein ions. Finally, we have shown that biomass with a large amount of protein acts as a selective adsorbent for Au3 + and Pd2 + in industrial waste.

There have been many studies on the adsorption of biomatadium iron ions but very few have reported the special adsorption of precious metal ions in the presence of different iron ions. We first investigated the competitive adsorption of precious metal ions onto the standard protein purified in the presence of various metal ions (Au3 +, Pd2 +, Pt4 +, Cu2 +, Ni2 +, and Zn2 +). All metal ions tested were 10 ppm each. Interestingly, all proteins were specifically tested for adsorbed Pd2 + and Au3 + to varying degrees, while small adsorption of Pt4 +, Cu2 +, Ni2 +, and Zn2 + was observed. Although many papers have suggested an interaction between amino acid residues (e.g., its) and different modes of transition metal (e.g., Cu2 + and Zn2 +), there is, to date, no report on the adsorption of metal ions. they are valuable to proteins. We believe that the present study explains for the first time that Pd2 + and Au3 + were selected for protein adsorption. It should be noted that the proteins prefer adsorbed Pd2 + and Au3 + in aqueous solution containing 01 staining. M HCl, because in most cases, the metal ions are in acidic conditions. Adsorption Isotherms of Precious Metal Ions in Proteins. The adsorption isotherms of precious metal ions (Au3 + and Pd2 +, 10 ppm each) on purified proteins [lysozyme, bovine serum albumin (BSA) and ovalbumin] were evaluated. All Au3 + and Pd2 + were finally adsorbed to a protein concentration of 0.6 g / L. The maximum adsorption capacity of the precious metal particles was calculated in the presence of excess metal ions (adsorption rate less than 50%, Table 1), based on the concentration of unreacted metal ions determined by atrosic absorption spectra, where protein concentration was set at 0.05 g / L, without Au-binding to lysozyme (0,1 g / L), and iron ion concentration was -10 ppm. All proteins examined here show a high adsorption capacity of Au3 + and Pd2 +. For example, BSA adsorbed 25 (1 Au ions) and 65 (2 Pd ions per protein molecule), and lysozyme adsorbed 2.6 (0.2 Au ions and 14 (2 Pd ions) per single protein molecule. At the highest level of adsorption (more than 80%), the adsorbed iron ions per molecule of protein are reduced due to the adsorption coefficient.

This work is partly presented in the event 23rd International Conference on Advanced Materials and Simulation during December 02-03, 2019 at Barcelona, Spain.