Contribution ID: **342** Type: **Poster**

M1Po2D-07: Using cryogenic milling for the recycling of multilayer packaging materials

Monday 10 July 2023 14:00 (2 hours)

In recent years, people in the world have greatly changed purchase and consumption habits due to the booming electronic commerce services and the effects of COVID-19 pandemic. In terms of daily diet, more and more people use online food ordering and delivery services (such as Uber Eats, DoorDash, Deliveroo, Foodpanda, etc.) and the amount of food packaging wastes has thus increased substantially. Multilayer packaging materials (MPMs), which are normally composed of paper, polymers, and/or aluminum, are widely used as food containers for delivery and storage; however the recycling rate of waste MPMs is very low. Without separating the component substances, the waste MPMs can not be introduced into the current recycling systems of paper, polymers, or aluminum, thus significantly increasing the difficulty and costs of the MPMs recycling. In this study, the cryogenic milling was used to assist the recycling of MPMs due to the difference in the property under an ultra low temperature between the component substances. Most polymers lose the ductile properties below their glass transition temperature, and it is therefore easier to reduce the size of polymers and to separate polymers from aluminum. The waste beverage containers manufactured by Tetra Pak were collected and used as experimental materials. This type of MPMs contains four layers of polyethylene, one layer of paper, one layer of aluminum foil, and inks. A vibratory micro mill (Fritsch, Pulverisette 0) with a special accessory (Cryo-box) was employed to conduct the cryogenic milling. The amplitude was set between 1 and 3 mm, and the grinding time was controlled from 5 to 15 min. The effects of the addition rate of liquid nitrogen were also examined in this study. After the cryogenic milling, the ground MPMs were separated into different particle size ranges and then digested with acids by using a microwave-assisted digestion procedure. The digests were analyzed with the inductively coupled plasma-optical emission spectrometry (ICP-OES, Thermo Scientific, iCAP PRO) to determine the concentration of aluminum. The results showed that a sufficient pre-cooling process with liquid nitrogen for MPMs was helpful to the following cryogenic milling. A pretreatment process of immersing the MPMs into water or water-ethanol mixtures also increased the efficiency of cryogenic milling. After the cryogenic milling, aluminum tended to remain in large particle size ranges, while most of paper and polyethylene were ground into small particles. However, aluminum was also ground into small particles with high grinding intensity (high amplitude, long grinding time, or both), and this may not be useful to the separation of the substances. Generally, the cryogenic milling can effectively reduce the particle size of MPMs and change the distributions of the component substances, thus making MPMs easier to be recycled. Some physical methods (flotation, electrostatic separation, etc.) or chemical extraction methods (acids, organic solutions, etc.) could be used to recover high-quality materials further.

Author: CHEN, Ying-Liang (Department of Resources Engineering, National Cheng Kung University)

Co-authors: Ms YA, Jie-Ying (Department of Resources Engineering, National Cheng Kung University); Mr HSIEH, Ping-Yu (Department of Resources Engineering, National Cheng Kung University); Dr LAI, Yi-Chieh (Department of Safety, Health and Environmental Engineering, National Kaohsiung University of Science and Technology)

Presenter: Dr LAI, Yi-Chieh (Department of Safety, Health and Environmental Engineering, National Kaohsiung University of Science and Technology)

Session Classification: M1Po2D: Cryogenic Materials Testing and Methods I