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Enhanced flotation of high density polyethylene and polyvinyl chloride mixtures based on clean corona modification

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ABSTRACT

The dramatic increase in waste plastics has caused harm to both human health and the environment. Due to the variety of plastic products and their complex components, it is a technical challenge to effectively separate them. High density polyethylene (HDPE) and polyvinyl chloride (PVC) both have a high detection frequency in the common solid waste streams like automobile shredder residue (ASR), and due to the similar properties of different plastics, their mixtures lack reliable separation methods. Specifically for this kind of mixtures, this work provided a novel separation strategy with prepositive corona modification and postpositive flotation units. To obtain the optimal separation parameters, flotation performance of HDPE and PVC were investigated under different modification conditions controlled by the corona polarity, discharge power and exposure time. Besides, the modification mechanism was revealed through multi-characterization tests on surface morphology, molecular weight, contact angle, and spectrums. The results showed that corona discharge can generate non-thermal plasma to activate the surfaces of HDPE and PVC, thereby increasing their floatability difference. Under the optimal conditions of 300 W positive discharge power and 8000 ms exposure time, HDPE turned into the sinking tail while PVC still accumulated in the floating product, leading to the maximum separation recovery and purity of 96.36% and 97.01%, respectively. Amorphous low-molecular weight oxidic substances emerged on the upper layer of polymers was verified by the multi-characterization, representing in varying degrees of oxidation and chain scission (HDPE > PVC). Since the corona modification is reagent-free-addition and rapid in-line process, this work showed great advantages in the total cost of separation (only 450.03 USD/t) and potential environmental benefits, which also paves a clean way for the recycling of HDPE and PVC.

1. Introduction

In recent decades, the global plastic production has increased dramatically. Due to its wide range of uses, light weight, strong stability and low price, plastics are used in various fields such as hygiene, construction, packaging, electronics, and transportation. According to statistical analysis of data, the total global plastic production in 2019 reached 353 million tons. Only 9% of plastic waste ends up being recycled. (OECD, 2022). However, due to the complex composition of plastics, it is difficult to degradation and extensive use will cause great harm to human health, ecological environment, wild animals and plants (Wang et al., 2016). Especially for some recent environmental occurrence investigations, microplastics are found in soil (Cao et al., 2021), sediments (Bronzo et al., 2021), organisms (Wootton et al., 2021), water bodies (Lu et al., 2021) monitored in. Traditional landfill or incineration disposal not only causes great waste of resources, but also exacerbates ecological and environmental problems such as land encroachment, greenhouse gas emissions, and accumulation of microplastic organisms (Li et al., 2018).

The recycling of plastics mainly includes material recycling, chemical recycling and energy recycling (Al-Salem et al., 2017). Through different levels of depolymerization and remodeling processes, homogeneous waste plastics can be recycled for alternative disposal to obtain oligomers or chemical monomers. For example, discarded PET plastic bottles can be reused by manufacturers to produce blankets through processing (Zhang et al., 2020a). However, different types of waste plastics cannot be mixed, and heterogeneous doping will result in embrittlement, discoloration and pollution of recycled defective products. Strict sorting by category is an important prerequisite for their recycling. Plastic recycling mainly originates from three waste mixtures:

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