Production of BTX via catalytic fast copyrolysis of printed circuit boards and waste tires using hierarchical ZSM-5 zeolites Part 2: Mixture of PCBs and Waste tires

[BACKGROUND] In the previous study (Part 1), catalytic fast pyrolysis (CFP) of waste printed circuit boards (PCBs) was studied using hierarchical ZSM-5 zeolite catalysts treated with 0.2, 0.5 and 0.8 M NaOH aqueous solutions (2MZ, 5MZ, and 8MZ, respectively). 2MZ was found to be the most effective for the catalytic deoxygenation of phenolic compounds, formed from the CFP of PCBs, into aromatics such as benzene, toluene, and xylene (BTX). Whereas the brominated compounds remain a major obstacle for the applicability of the pyrolysis products. In this study, the ex-situ CFP of a mixture of PCBs and waste tires (WTs) was studied using the 2MZ catalyst and biochar (BC). The evaluation of the catalyst performance in the fast co-pyrolysis of PCBs and WTs (PCB/WT) was carried out to extend the catalyst applicability of 2MZ.

[EXPERIMENTAL] WTs were provided by a Japanese recycling company. The details of experimental conditions were described in the previous note (Part 1). In brief, commercially obtained epoxy PCBs were pulverized into fine particles (<150 μm). The particle size of 2MZ catalyst was less than 10 μm. In the CFP experiments, BC was packed in a quartz tube as the upper layer and 2MZ as the lower layer in a 1:2 mass ratio (denoted as 0.5BC/2MZ) was used. Evaluation of catalytic reactions was done by a GC/MS system equipped with a Tandem μ-Reactor (Rx-3050TR) and a cryo-trap.

[RESULTS] Brominated organic compounds formed in the pyrolysis of PCBs reduces the catalytic activity of 2MZ during the repeated CFP experiments. While the BC minerals likely enhance the organic Br to inorganic Br (e.g., HBr, Br_2) conversion. In addition, hydrocarbon-rich WTs have been reported to favor the debromination performance and promote the formation of aromatics. Here, CFP of PCB/WT was studied using 0.5BC/2MZ, varying the blending ratio of WT to PCB, and the results are shown in Fig. 1. The catalytic fast copyrolysis of PCB/WT significantly improves the product quality compared to the PCB pyrolysis alone, especially in BTX formation (Fig. 1 (a)). Additionally, the synergistic effect of catalytic fast copyrolysis of PCB/WT produces higher naphthalene and methylnaphthalene yields than expected (Fig. 1 (b)). It should be noted that no heteroatom (Br/S/N) compounds were detected. Typical pyrolyzates in the pyrolysis of WTs are known to be olefins (such as 1,3-butadiene, isoprene, and D-limonene) and aromatics. On the other hand, in the CFP of WTs over 0.5BC/2MZ, the typical olefins and the major products of styrene and α-methylstyrene were not observed. However, the highest BTX and alkylbenzene yields were obtained, indicating that the Diels−Alder reaction of olefins, the scission and cyclization of D-limonene, and the dehydrogenation of styrene were significantly promoted by 0.5BC/2MZ. It is known that catalysts with strong Lewis and Brønsted acids promote the Diels−Alder reaction. The Lewis acids promote the Diels−Alder reaction of olefins to form six-membered rings, which is followed by dehydrogenation and dealkylation reactions on the Brønsted acid sites to form BTX and alkylbenzenes. The hydrogen transfer and dealkylation reactions of styrene were also promoted by the strong Brønsted acid sites in 2MZ. Overall, the obtained results manifest that the combination of BC and hierarchical 2MZ catalyst can reach the greatest debromination and BTX production from PCB pyrolysis; the PCB/WT catalytic copyrolysis can further result in a higher yield of BTX and mitigate the catalyst deactivation simultaneously.

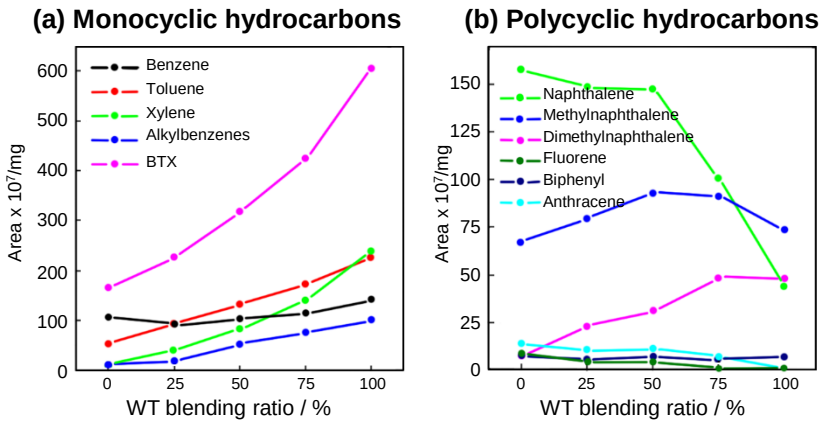

Fig. 1 Yields of the major products obtained from the catalytic fast co-pyrolysis of PCB and WT with the 0.5BC/2MZ catalyst.

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Keywords : BTX, e-Waste, WEEE, Printed circuit board, PCB, Waste tire, ZSM-5, Catalytic fast pyrolysis, CFP

Products used : Tandem μ-Reactor (Rx-3050TR)

Applications : Plastic waste conversion, BTX formation

Related technical notes : RXA-006E, PYA1-116E, RXA-011E

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