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Separation Process Development for Poly(vinyl chloride) and Copper Recovery from Wire Harness

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[Introduction]
Thin electric cables of mm-order diameter are often used for wire harnesses in automobiles as well as in electrical and electronic equipment. At the recycling stage, current peeling equipment cannot handle thin cables, while shredding techniques also produce fine particles, resulting in low-purity separation of both the Cu and the PVC. Therefore, development of an efficient separation process for PVC and Cu recovery from thin electric cables is strongly required. Herein, two processes combining chemical and mechanical methods were developed to separate PVC and Cu for recycling waste electric cables (Fig. 1).

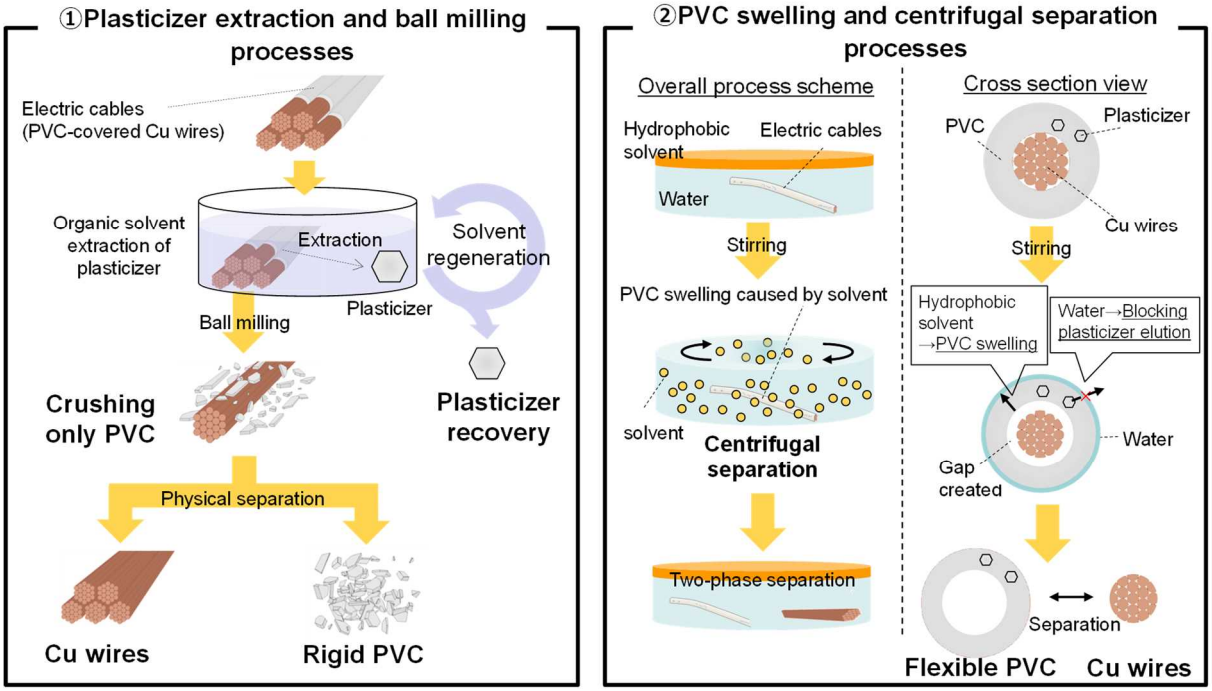

Fig. 1 Developed separation processes.

[Plasticizer extraction and ball milling processes[1,2]]
One process that includes plasticizer extraction and ball milling was introduced to recycle Cu and de-plasticized PVC simultaneously. The plasticizer was extracted from the electric cables to yield “brittle” PVC covering. Then, the hardened electric cables were subjected to ball milling, which crushed only the

PVC covering and removed it from the Cu wires. Finally, the PVC covering and Cu were separated by simple mesh sieving. This approach finally achieved complete separation for all tested thin electric cables (purchased cables with diameters of 1.5, 2.1, and 2.7 mm, and used wire harnesses), with the Cu selectivity over 99.5 wt% (Fig. 2).

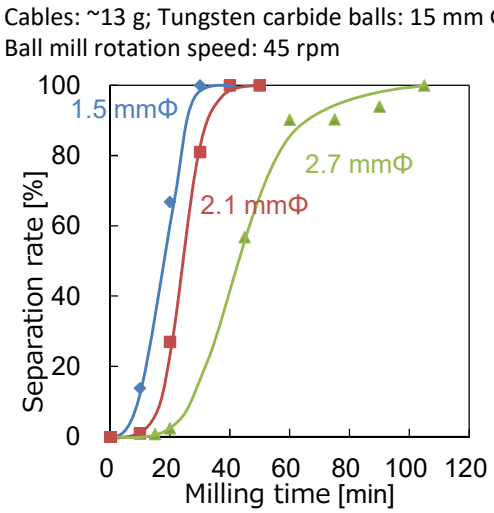

Fig. 2 Relationship between separation rate and ball milling time for electric cables of different sizes after crushing.

[PVC swelling and centrifugal separation[3,4]]

Another process, combining PVC swelling and centrifugal separation, was used to recover plasticizer embedded PVC and high-purity Cu simultaneously. The PVC covering was caused to swell in an organic solvent at ambient temperatures, creating a gap between the covering and the copper wire and facilitating centrifugal separation. A mixed solvent of butyl acetate and water with a volume ratio of 10:90 butyl acetate:water, achieved complete separation, with more than 80% of the plasticizer remaining in the PVC covering.

In conclusion, this work achieved recovery of high-purity copper and PVC with controlled plasticizer content from thin waste cables. We expect that the recovered copper can be directly used as a copper cable source due to its high purity, and the plasticizer-extracted PVC and plasticizer-embedded PVC can be recycled as rigid and flexible PVC sources, respectively.

[Publications]

1. Xu, J., Tazawa, N., Kumagai, S.,* Kameda, T., Saito, Y. and Yoshioka, T. (2018) Simultaneous recovery of high-purity copper and polyvinyl chloride from thin electric cables by plasticizer extraction and ball milling. *RSC Advances*, 8: 6893-6903.
2. Xu, J., Lu, J., Kumagai, S.,* Kameda, T., Saito Y., Takahashi, K., Hayashi, H. and Yoshioka, T. (2019) Validation of a deplasticizer–ball milling method for separating Cu and PVC from thin electric cables: A simulation and experimental approach. *Waste Management,* 82: 220-230.
3. Xu, J., Kumagai, S.,* Kameda, T., Saito, Y., Takahashi, K., Hayashi, H. and Yoshioka, T. (2019) Separation of Copper and Polyvinyl Chloride from Thin Waste Electric Cables: A Combined PVC-swelling and Centrifugal Approach. *Waste Management,* 89: 27-36.
4. Lu, J., Xu, J., Kumagai, S.,* Kameda, T., Saito, Y., Takahashi, K., Hayashi, H. and Yoshioka, T. (2019) Separation mechanism of polyvinyl chloride and copper components from swollen electric cables by mechanical agitation. *Waste Management,* 93: 54-62.