

Recycling of copper, PVC, and plasticizer from waste wire harnesses by wet ball milling

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1. Introduction

Wire harness?

Cables (<5 mm diameter)



Connectors

Widely applied techniques in cables recycling [1-7]

1. Stripping or peeling



Issues: cannot handled thin cables

2. Comminution and then recovery

Comminution of cables



Issues: low degree of liberation result in low recovery and grade of both PVC and copper

3. PVC coating dissolution

Plasticizer • Stabilizers • CaCO₃



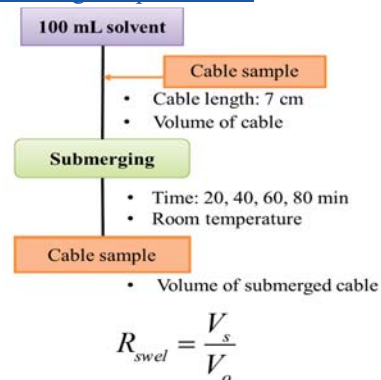
Issues: Complex recovery of PVC constituents

- > Cu wires (70-75 wt%)
- > PVC coating (30-25 wt%)
- Plasticizers (20-40 wt%)
- CaCO₃
- Stabilizers } 6-10 wt%

Objectives of this study: Simultaneous recovery of copper, PVC, and plasticizer from thin WH cables at moderate physical impact in the presence of suitable organic solvent without being PVC dissolve.

3. Experimental procedures and apparatus

Swelling test procedures

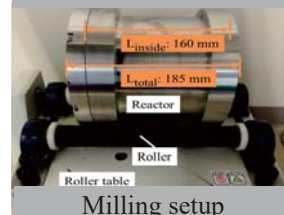


V_s and V_o are the volumes of the cables after and before submersion, determined by electronic densimeter.

Mill apparatus outlook



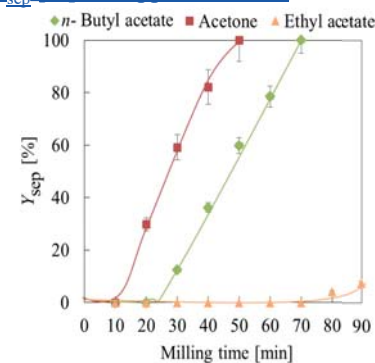
Inside view of reactor



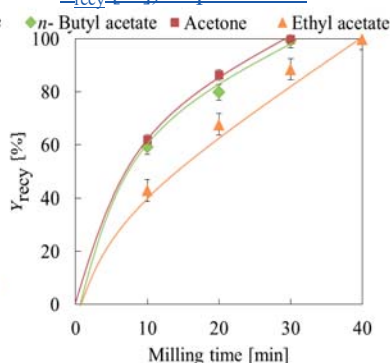
Milling setup

4.1. Separation yield (Y_{sep}) and recycled yield (Y_{recy})

Y_{sep} [%] of copper and PVC



Y_{recy} [%] of plasticizer



As results, acetone showed greater separation rate than that of *n*-butyl acetate, may due to conversation of milling energy into heat, result in greater influenced on swelling degree of acetone.

The quantitative DINP yield was recovered during milling in presence of each respective solvents.

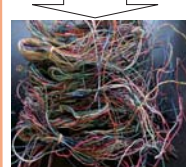
2. Materials and methods

Materials

As received WH

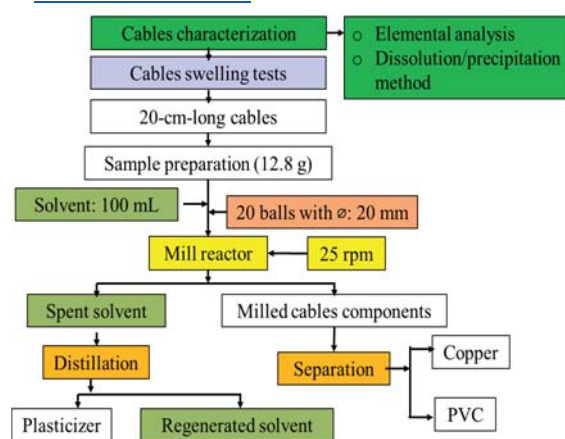


Sorting



Sorted out cables

Methods: flow chart



Applied swelling solvents: *n*-butyl acetate, acetone, and ethyl acetate

4. Results and discussion

Results of cables characterization

Elemental analysis

Cable diameter [mm]	Weight composition [wt%]					Balanc e ^a
	C	H	N	Cl		
1.0	46.7	6.2	- ^b	35.7	11.5	
1.2	45.4	5.9	-	35.3	13.4	
2.0	45.0	5.8	-	33.4	15.8	

^aMainly oxygen and ash. ^bNot detected.

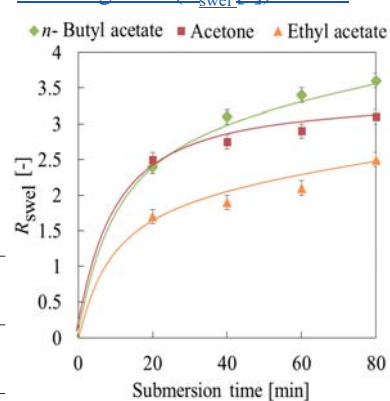
Compositional analysis

Components	[wt%]
Cu	72
PVC	28
PVC composition [wt%]	
Plasticizer ^a	21.4
Insoluble constituents	7
PVC resin	71.6

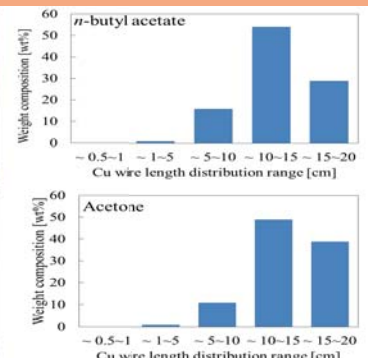
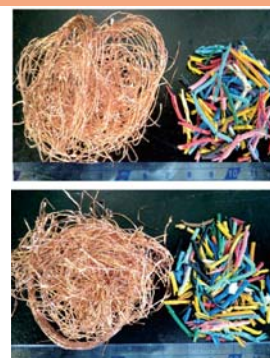
^a determined by ¹H NMR

Order of swelling power: *n*-butyl acetate > acetone > ethyl acetate

Swelling ratio (R_{swel} [-]) results



4.2. Photographic images of recovered Cu and PVC



5. Conclusion

- We, therefore simultaneously recycled Copper, PVC, and plasticizer with 100% recovery and grade by established technique. Approximately 90% retrieved copper wires were >10 cm long.
- De-plasticized PVC, and plasticizer may re-use in PVC industries.