

# Separation of Al and PVC from Waste Pharmaceutical Blisters for Sustainable Recycling

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Figure 1: Pharmaceutical blisters used in the study: PVC film blister and aluminum foil blister pack

## Introduction

- In the context of the COVID-19 pandemic, the rapid increase in demand from pharmaceutical packaging means that the large volume of this waste is increasing sharply. About 600 tons of medical waste is generated daily in hospitals and medical facilities in Vietnam.
- The plastic most commonly used in these pharmaceutical blister packs is polyvinyl chloride (PVC). PVC is also a low-cost plastic, saving production costs while the output quality of the product is still guaranteed. Aluminum foil is used as the lid material for pharmaceutical blisters, this is a metal foil that can ensure the strength of packaging.
- Currently, the discarded pharmaceutical blister packs are mainly disposed of by burning and burying with municipal solid waste. Burning plastic can cause harmful gases such as dioxins and furans due to the chlorine content contained in PVC, which pollutes the air as well as affects human health. Furthermore, incineration also depletes recycled aluminum in the context of a circular metal economy.
- In this study, the NH<sub>3</sub>-NH<sub>4</sub>Cl-H<sub>2</sub>O solution was used to study the ability to separate aluminum foil and PVC from pharmaceutical blisters based on the weakened adhesion between both layers and cause these layers to gradually separate from each other.

## Results & Discussion

### Investigation of optimal conditions when using NH<sub>3</sub>-NH<sub>4</sub>Cl-H<sub>2</sub>O solution of Al/PVC separation

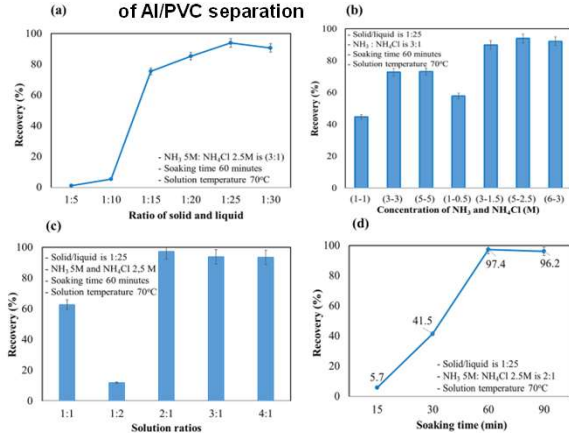


Figure 2: Recovery of aluminum and plastic separation at different solid-liquid ratio (a), solution concentrations (b), solution ratios (c) and soaking time (d)

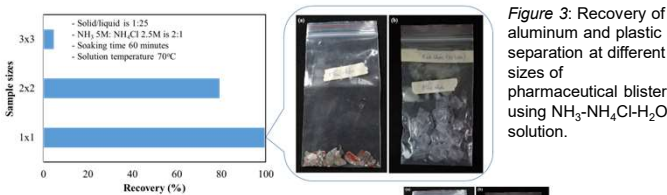


Figure 3: Recovery of aluminum and plastic separation at different sizes of pharmaceutical blister using NH<sub>3</sub>-NH<sub>4</sub>Cl-H<sub>2</sub>O solution.

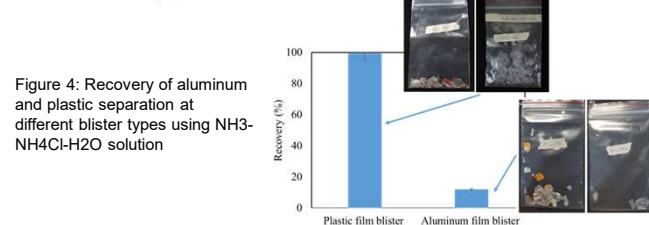


Figure 4: Recovery of aluminum and plastic separation at different blister types using NH<sub>3</sub>-NH<sub>4</sub>Cl-H<sub>2</sub>O solution

- Optimal plastic separation and aluminum recovery conditions: Sample/solution ratio (1:2.5) (g/ml); the ratio of 5M NH<sub>3</sub> solution: NH<sub>4</sub>Cl is 2:1; sample soaking time 60 minutes; temperature 70°C, Sample size is 1x1cm.
- A high recovery (99.5%) was observed in the case of PVC film blister with the amount of aluminum and PVC obtained was 0.22 g (11%) and 1.75 g (87.5%), respectively.
- The amount of dissolved aluminum (Al<sup>3+</sup>) has very low density ranged from 0 to 0.03 g.
- Separation efficiency for aluminum foil blisters is very low (12.0%).

- The dissolved aluminum fraction was determined by ICP and titrated with HCl and KF reagent for comparison.
- The insoluble aluminum foil was separated from the solid mixture using froth flotation (airflow rate of 2 l/min).

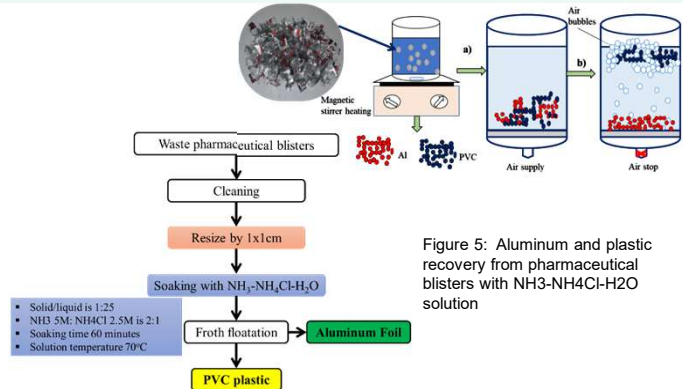


Figure 5: Aluminum and plastic recovery from pharmaceutical blisters with NH<sub>3</sub>-NH<sub>4</sub>Cl-H<sub>2</sub>O solution

### The total profit

$$\text{Profit} = [\text{Total sale (aluminum + PVC)}] - [\text{total cost (electricity + chemicals + labor)}]$$

### Economic analysis of aluminum and plastic recovery from 1000 kg pharmaceutical blisters with NH<sub>3</sub>-NH<sub>4</sub>Cl-H<sub>2</sub>O solution

Items	Amount	Price	Money (VND)	Money (USD)
Electricity	124,8 kW	3,000 VND/kW	374,400	16,14
Water	10 m <sup>3</sup>	10,800 VND/m <sup>3</sup>	108,000	4,66
NH <sub>3</sub>	6944 l	11,000 VND/can	2,546,133	109,77
NH <sub>4</sub> Cl	1125 kg	25,500 VND/bao	1,147,500	49,47
Labor	-	-	208,802	9,00
Aluminum	110 kg	33,000 VND/kg	3,630,000	156,50
PVC	890 kg	13,000 VND/kg	11,570,000	498,81
<b>Total</b>			<b>10,815,165</b>	<b>466,27</b>

## Conclusions

- The project has developed a method to separate aluminum and plastic; increase recycling efficiency, reduce environmental pollution, and limit waste of natural resources. The recovery of aluminum and PVC is up to 99.5%.
- The study contributes not only to increasing recycling efficiency but also getting cost benefits from the amount of aluminum and PVC obtained after the process. These findings have contributed to reducing environmental pollution while avoiding wasting natural resources based on potential recycling of waste pharmaceutical blisters.