Journal of Metals, Materials and Minerals. Vol. 13 No.2 pp. 79-85, 2004.

Separation of PET from PET&PVC Mixture by Froth Flotation Technique

Somsak SAISINCHAI*

Department of Mining and Petroleum Engineering
Faculty of Engineering, Chulalongkorn University Bangkok, Thailand

ABSTRACT

The froth flotation technique can be successfully applied for the separation of Polyethylene Terephthalate (PET) from a mixture of Polyethylene Terephthalate and Polyvinyl Chloride (PVC) by using Polyvinyl Pyrrolidone (PVP) as a wetting agent and Methyl Isobuthyl Carbinol (MIBC) as a frother or foaming agent. Three groups of pseudo mixture were prepared by the mixing of PET and PVC flakes at volume ratios of 75:25, 50:50, and 25:75, respectively. Optimum conditions for the separation of PET from each pseudo mixture were then investigated.

The study indicated that the separation of the plastic flakes was greatly influenced by both PVP concentration and a number of cleaning flotation stages. The optimum condition for each pseudo mixture can be summarized as follows: 0.01 mg/l of PVP concentration at the 3rd stage of cleaning flotation for the 75:25 pseudo mixtures; 0.01 mg/l of PVP concentration at the 2nd stage of cleaning flotation for the 50:50 pseudo mixtures, and 0.0025 mg/l of PVP concentration the 3rd stage of cleaning flotation for the 75:25 pseudo mixtures.

*To whom the correspondence should be addressed:
E-mail: fmnsss@kankrow.eng.chula.ac.th

INTRODUCTION

A great amount of plastics are found in municipal waste, most of which come from household commodities, automobile scraps, televisions and personal computers, etc. At present, most of the waste plastics are disposed by incineration and reclamation. Bearing this in mind, it is essential to develop a recycling system for those plastic wastes in order to avoid exhaustion of the petroleum products and the environmental destruction.

To recycle plastic waste, it is necessary to separate the plastics from each other. Plastics having different density can be easily separated, while quite difficult for the separation of PET and PVC, which have similar density (1,300 kg/m^3 for PET, and 1,500 kg/m^3 for PVC). Various studies on the PET and PVC separation have been employed. Nakajima, J. *et al*. (1999) initially reported the removal of PVC from PET&PVC mixture by air separation (Nakajima, *et al.* 1999). Carlini, *et al.* (1995) investigated the separation of PET from PET&PVC mixture by means of differential thermal behaviors of the both plastics (Carlimi, *et al.* 1995). De Haan, *et al.* (1997) assessed the technical feasibility of the electrostatic separation of PET and PVC (De Haan, *et al.* 1997). Yoneda, *et al.* (1998) indicated that PET bottles and PVC bottles could be identified respectably by the IR data of adsorption wavelength; therefore it might be possible to separate the PET bottles from the PVC bottles (Yonneda, *et al.* 1998).

In the present study, the froth flotation technique has been employed to separate PET from the PET&PVC mixtures by taking advantage of the difference in surface wet ability resulting from adsorbing surfactant on the plastic particle surface.

EXPERIMENT

Sample

Polyethylene Terephthalate (PET) and Polyvinyl Chloride (PVC) flakes used in this study were prepared by shredding into small pieces having size 10x10 mm and thickness 1 mm using a cutter for plastic. The density of the used PET and PVC flakes was 0.13 and 0.15 g/m^3 respectively. Three groups of pseudo mixture were prepared by mixing the PET and PVC flakes at volume ratios of 75:25, 50:50, and 25:75, respectively. The PET content in each group of the pseudo mixture is 72%, 46%, and 22% by weight, respectively.

Experimental Procedures

A flotation machine (Kyoto University Type or Batch Type), as shown in figure 1, was used to determine the floatability behavior of each sample, and impeller speed was set at 1,720 rpm.

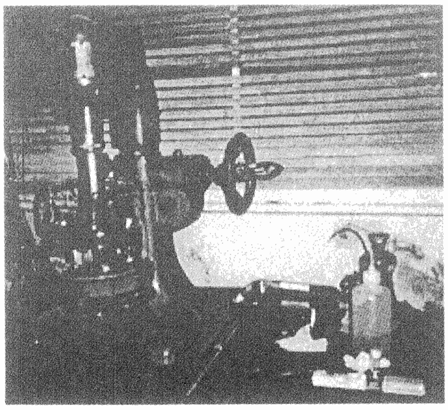

Figure 1 Flotation machine (Kyoto University Type).

Figure 2 shows a simplified process of PET & PVC separation in a batch type flotation cell. At the first stage of flotation, usually called "Rougher Flotation Stage", a pseudo mixture containing 100 pieces of plastic flake was fed into a 1,800 ml flotation cell with water filled, followed with addition of PVP as a wetting agent, and then stirred, usually called "Conditioning", for 10 minutes. Then, 6 drops of MIBC frother was added to stabilize air bubbles continuously introduced into the water mixture for 10 minutes. At this stage, most of the PVC flakes gradually sunk while the PET flakes floated to the top of the flotation cell. PET content in the floated portion was counted while the sunken portion was removed. Then, the floated portion was fed into the same flotation cell for re-flotation in order to increase the PET content. This stage is usually called the 1st cleaner stage. If the PVC flakes still contaminate in the floated portion, the next cleaner stage and so on, the 2nd cleaner and/or the 3rd cleaner process, should be operated until obtaining the maximum PET content.

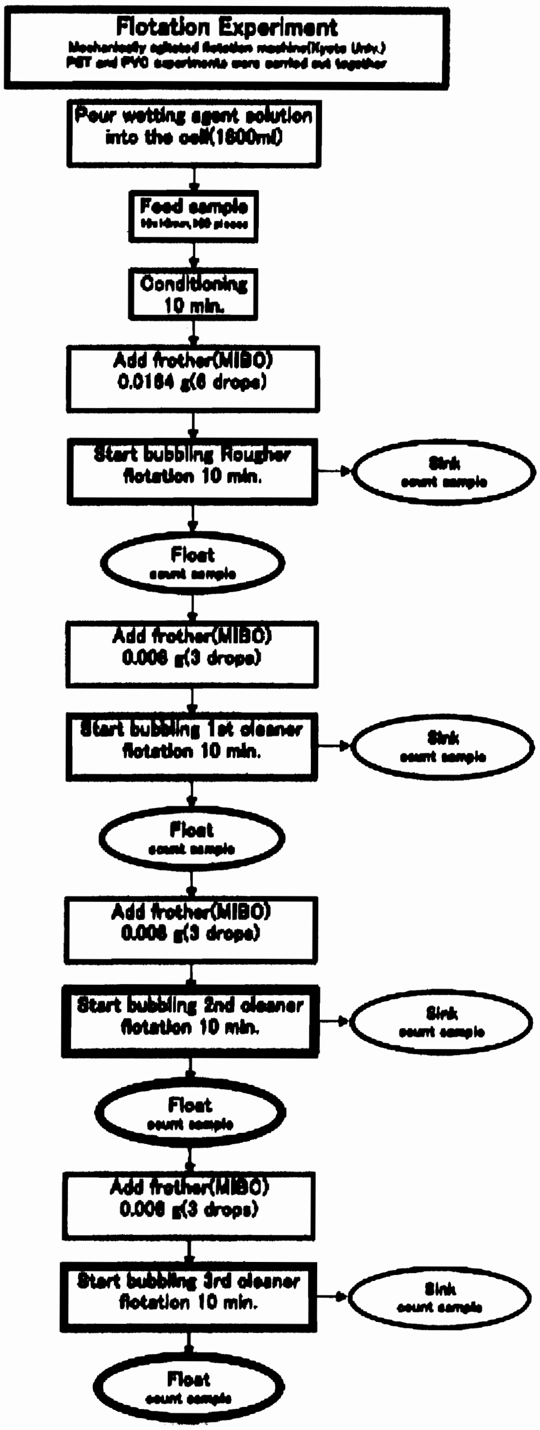

Figure 2 Simplified diagram for separation of PET and PVC.

RESULTS AND DISCUSSION

The flotation cell usually provides the sample fed into the cell with their gravity and buoyancy force of air bubbles. Plastic particles are naturally hydrophobic and are therefore amenable to be separated by flotation. Unfortunately, separation of plastic particles is difficult unless the other components are rendered hydrophilic. In this case, PVC readily adsorbed the PVP wetting agent better than PET. As a result, by selective adsorption onto the PVC particles, it is possible to change PVC's hydrophilic / hydrophobic properties while the PET remains virtually unaffected. Under these conditions, the PVC surface will be rendered hydrophilic while the PET will remain hydrophobic. When PVC is impregnated with PVP, separation from PET is possible by bubbling air through a suspension of the plastic flakes in water. Air bubbles have a high affinity for water repellent surfaces. This selectivity allows air bubbles to preferentially attach to the PET flakes, while the PVC flakes show a low affinity. Consequently, the PET floats while the PVC sinks.

The floatability behavior of the samples is graphically represented as % PET recovery and % PET content in each flotation stage. Graphical representations also indicate the relationship of %PET recovery, %PET content and wetting agent concentration. Figure 3 shows the relationship of %PET recovery as well as %PET content at each flotation stage of the 50:50 pseudo mixtures. It was found that %PET recovery gradually decreased at each flotation stage when using 0.02 mg/l PVP concentration, while constant at 100% recovery when using 0.01 mg/l PVP concentration. This suggested that the PET surface is rendered slightly hydrophilic at high PVP concentration; hence, some PET flakes sink.

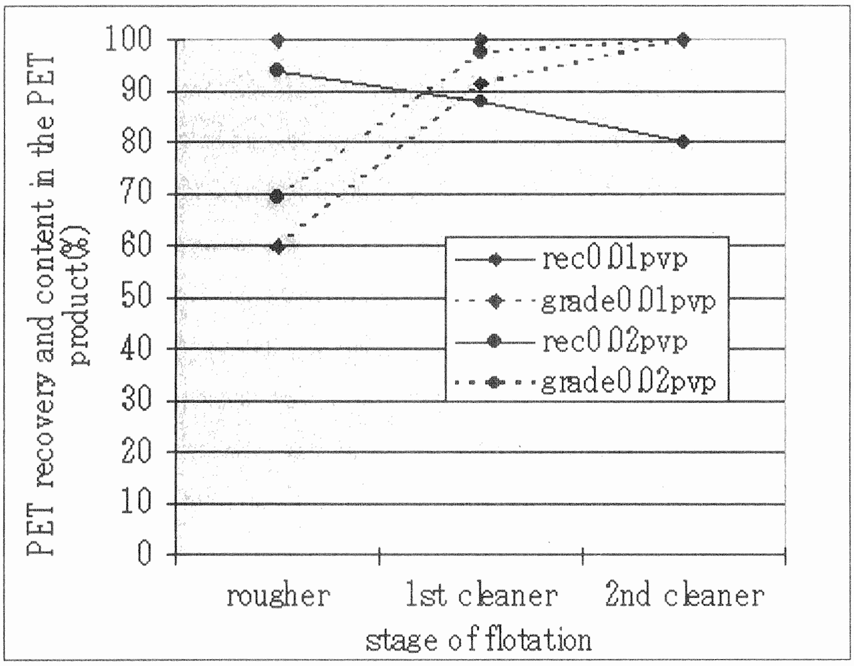

Figure 3 PET content and recovery in the PET concentrate as a function of PVP concentration with PET feed content 46.43%.

Figure 3 also shows that the maximum PET content can be obtained at the 2nd cleaner flotation stage with 0.01 mg/l PVP concentration.

Figure 4 shows the relationship of %PET recovery as well as %PET content at each flotation stage of the three groups of pseudo mixtures with constant PVP concentration at 0.01 mg/l. It is observed that the maximum PET recovery can be obtained for the pseudo mixtures having 72% and 46% by weight of PET contents, while only 44% PET recovery in the case of pseudo mixtures having 22% by weight of PET contents. This indicates that the PET surface can adsorb the excess PVP and becomes hydrophilic as well. Therefore, utilization of lower PVP concentration is suggested for the 22%PET content mixtures.

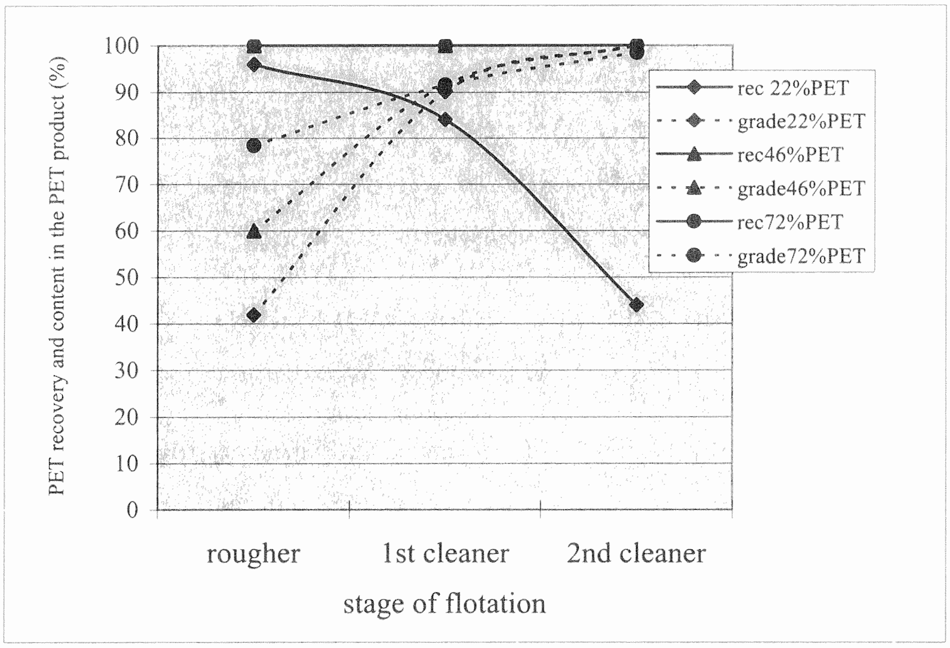

Figure 4 PET content and recovery in the PET concentrate as a function of PET feed content with PVP $1x10^{-2}$ mg/l.

Figure 5 shows the relationship of %PET recovery as well as %PET content at each flotation stage of the pseudo mixtures having 22% PET content by using PVP concentration at 0.005 mg/l. and 0.0025 mg/l. It is indicated that maximum PET recovery can be obtained when using 0.0025 mg/l PVP concentration at the 3rd cleaning stage.

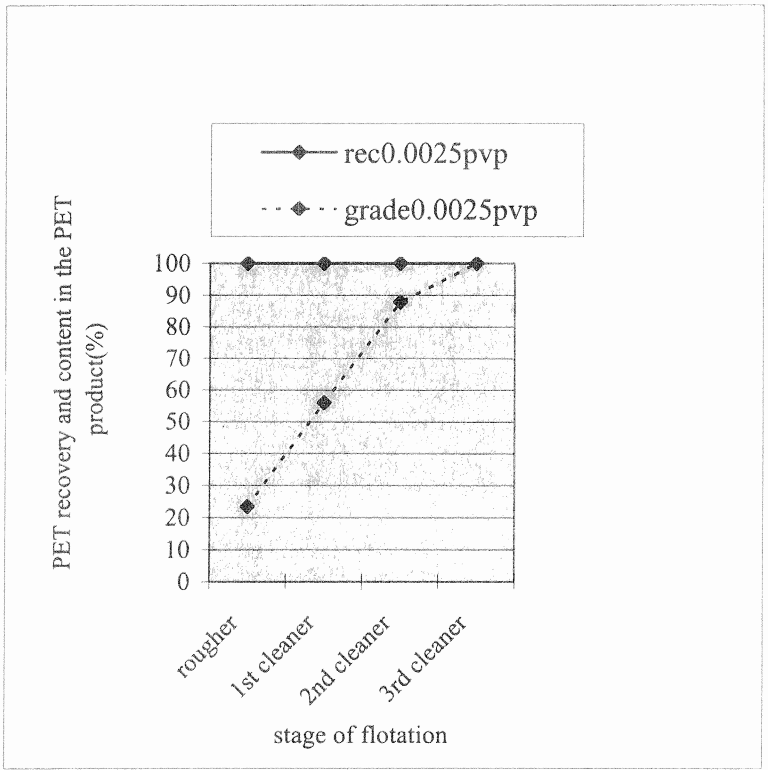

Figure 5 PET content and recovery in the PET concentrate as a function of PVP concentration with PET feed content 22%.

CONCLUSION

As plastics are produced from petroleum products and not biodegradable while recyclable if well separated, recovery and recycling of plastics become important for both resources and environmental conservation. Hence, there is a growing recognition of the need to develop technology and system for plastic recovery and recycle. Plastics having a different density can be easily separated, while it is quite difficult to separate plastics that have a similar density. PET and PVC is one of the cases where 1,300 kg/m^3 for PET, and 1,500 kg/m^3 for PVC. Fundamental study was pursued with the separation of PET and PVC flakes by means of froth flotation, using three groups of pseudo plastic mixture. Results of the study can be summarized as follows.

- For the pseudo mixture having 75:25 volume ratio of PET & PVC or having 72% by weight of PET content, the best separation or maximum PET recovery can be obtained when using 0.01 mg/l PVP concentration at the 3rd stage of cleaning flotation. At this condition, both %PET recovery and %PET content were 100%.

- For the pseudo mixture having 50:50 volume ratio of PET & PVC or having 46% by weight of PET content, best separation or maximum PET recovery can be obtained when using 0.01 mg/l PVP concentration at the 2nd stage of cleaning flotation. At this condition, both %PET recovery and %PET content were 100%.

- For the pseudo mixture having a 25:75 volume ratio of PET & PVC or having 22% by weight of PET content, best separation or maximum PET recovery can be obtained when using 0.0025 mg/l PVP concentration at the 3rd stage of cleaning flotation. At this condition, both %PET recovery and %PET content were 100%.

ACKNOWLEDGEMENTS

The author would like to thank Professor Shuji Owada and his nice students in Owada Laboratory, Department of Resources and Environmental Engineering, School of Science and Engineering, Waseda University, Tokyo, Japan, for some basic data and facilities. The author also would like to thank TJTTP-JBIC for providing financial support through the government of Thailand.

REFERENCES

Nakajima, J., Nakazawa, H., Sato, H. and Kudo, Y. 1999. Removal of PVC from PET by air separation. *The 5th Int. Symposium on East Asian Recycling Technology*. Japan : 269-272.

Carlini, M., Mustacchi, C.,Villarini, M. and Di Ianni, P. 1995. Innovative pilot-plant for plastic separation: thermodynamic fluid model and experiment analysis. *Proc. Int. Conf. Solid Waste Technol. Manage. 11th* : 7.

De Haan, P. H., De Goeje, M. P. and Fraunholez, N. 1997. A technical and economic assessment of electrostatic separation of mixed plastic waste. *Mater.,Funct. Des.,Proc.Eur.Conf. Adv. Master. Processes Appl., 5th*. Netherlands Society for Materials Science : 2,2/215-2/218.

Yonneda, K., Hirabayashi, S., Akaizawa, Y., Yonezawa, T. and Kimura, T. 1988. *Jpn. Kokai Tokkyo* : 27.

(Revised version accepted March 23, 2004)