Selective Separation of PET from PVC for Plastics Recycling

23742 PDF

Joey Yang
Advanced Processing Technologies, Inc.

A new technology is using froth flotation to separate PET from PVC for plastics recycling. Because of the simplicity of the process and low price of the reagent used, the technology requires low capital investment and low operating cost.

Introduction

U.S. plastics production has grown by ~10% each year in the last several years. Six polymers account for about 80% of the total polymer production: low-density polyethylene, high-density polyethylene (HDPE), polypropylene, polyvinyl chloride (PVC), polystyrene, and polyethylene terephthalate (PET).

Plastics recycling is hampered by the polymers' different melting points and thermal stabilities, which contaminate the main polymer product and reduce the quality and the price of the recycled plastic. The inability to separate a complex mixture of plastics limits the recycling and reuse of several polymers.

PVC and PET cannot be separated using conventional gravity separation techniques because their specific gravities overlap; PVC density ranges between 1.32 to 1.37 g/cc and PET density varies from 1.33 to 1.37 g/cc.

Currently, recycling technologies use relatively homogeneous plastics because hand-sorting waste feed is too expensive. Many promising technologies for separating mixed thermoplastics are being investigated, but they are still uneconomical and unreliable.

Concept Description

A technology using froth flotation is being developed to separate PVC and PET. The process consists of a mixing step and a flotation step. The surface chemistry of the two polymers is modified in a mixing step before the flotation process.

PVC and PET can be separated through froth flotation because of the differences in their surface properties. For example, the surface tension and critical surface tension of wetting at 20°C are 42 and 39 dyne/cm for PVCs and 45 and 43 dyne/cm for PETs.

Because of PVC's and PET's different chemical compositions, their surface properties can be modified before flotation by adjusting the aqueous solution chemistry. In other words, the problem can be viewed as selective separation of oxide material from chloride material. The literature indicates that several water-soluble organic compounds (amines, sulfates, alcohols, glycols) can adsorb preferentially at the PET/aqueous phase or PVC/aqueous phase interface and therefore can modify polymer surface properties (Dann 1970; Wolfram

1966). The changes were observed in the critical surface tension of wetting for both PET and PVC, as affected by dissolved organic compounds (Dann 1970). These observations indicate a potential for modifying polymer surface properties.

Economics and Market Potential

Selective separation of PET and PVC from mixed thermoplastics in plastic recycling offers the potential to reduce solid waste streams and fossil fuel consumption because recycled plastics can partially displace virgin polymers produced from refined fossil fuels. A typical facility for recycling post-consumer plastics could realize a six- to twelve-month payback.

Using this technology to separate PET from PVC could increase the sale price for both recycled products by more than 30% because of their higher quality. Because of the simplicity of the process and low price of the reagent used, this new technology requires low capital investment and low operating cost. In addition, the process offers reduced energy consumption compared with the manufacture of virgin polymer.

The potential market for clean recycled PET includes most product applications that use virgin plastic, excluding food applications, currently served by virgin PET and HDPE. The potential market also includes applications currently served by other virgin polymers or other materials. For example, PET has been mentioned recently as a good material for producing home insulation. If a clean PET can be made available by this technology, markets are likely to develop to use large quantities of the PET/PVC waste collected.

Key Experimental Results

One of the most crucial tasks for successfully separating PET and PVC is surface characterization of these two polymers. In this task, the technical feasibility of the proposed separation technique can be established through studies on the thermodynamics of wetting and bubble-particle contact.

For surface characterization, contact angles were measured using both the sessile-drop and captive-bubble techniques for air/aqueous phases of both PET and PVC. Virgin PVC polymer and the PET recovered from plastic products were examined. Surface-active additives of different compositions and concentrations were used to modify the surface/interfacial properties of these systems. While both PET and PVC are hydrophobic, adding appropriate reagent(s) that adsorb at surfaces of PET and PVC can render PET hydrophilic while maintaining the hydrophobicity of PVC. This provides a fundamental basis for the selective flotation of PVC from PET.

After the contact angles were measured, the flotation test used a proprietary chemical reagent at a total dosage of 10^{-5} M. The flotation pH was controlled at 10.5, and the particle size of PET and PVC was 3x4 mm. Because this particle size is not ideal for common flotation practice (the ideal particle size for common flotation practice should be <28 mesh), a slow flotation method was used. On the other hand, the separation efficiency for particles with a size <28 mesh should be superior to the flotation test data.

The first flotation test used PET (pellets) and 10% talc-filled PVC (virgin, flexible). In this case, the talc-filled PVC particles were hydrophilic and remained as a tailing product, while the PET particles were present in the froth product. A second flotation test used PET (pellets) and reground PVC (flexible). In this case, the PVC was rendered more hydrophobic, compared with the hydrophobicity of PET under the same reagent addition; the PVC was then found in the froth product, while the PET remained as a tailing product. In each case, an excellent flotation separation of PET from PVC was achieved as designed.

Future Development Needs

With the results obtained from the preliminary experimental work, future development includes refining the concept, establishing the optimal reagent conditioning and flotation conditions, conducting a large-scale feasibility test, and doing a detailed cost and economics analysis.

References

Dann, J.R. 1979. "Focus Involved in the Adhesive Process." *J. Colloid Interface Sci.* 32:302-320.

Wolfram, E. 1966. "Neuere Erge bnisse über die benetzung von Polymeren." *Kolloid Zeitschrift und Zeitschrift für Polymere.* 211:84-94.

For more information, contact

Joey Yang or
Ye Yi
Advanced Processing
Technologies, Inc.
P.O. Box 58131
Salt Lake City, UT 84158-0131
Phone: (801) 581-1792
Fax: (801) 581-0599

Compiled by
Pacific Northwest Laboratory for the U.S. Department of Energy, Innovative Concepts Program 590240. This flier was printed on recycled paper.