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Development of Technology for Removal of PCBs

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Purpose of Work

■ Objective

- Develop viable strategies and technology for the control and minimization or elimination of polychlorinated biphenyls (PCBs) and other substances of concern (SOCs) from recycled automotive materials

■ Approach

- Identify efficient and environmentally acceptable process solutions for removal of contaminants, including PCBs, from materials recovered from shredder residue
- Define variances in analytical procedures/test results for PCB analysis

Previous Review Comments

- Recommendation: Future work should be focused on the following,
 - Development of technologies to remove residual contaminants from recycled materials to meet U.S. regulations, i.e., removal PCBs
 - *ECO2 Plastics Inc.*
 - *Vacuum devolatilization (Midland Compounding)*
 - *One other undisclosed compounder*
 - *Argonne process*

PCB Issue

- The original interpretation of the TOSCA regulations by the EPA was that you could not reintroduce into commerce plastics from shredder residue
 - Unless you could prove that no PCBs entered the shredder
- North American Automotive Association, ISRI, AHAM, APC, and Argonne formed the Coalition for Responsible Recycling
 - Obtained the present interpretation of 2 ppm PCBs threshold to reintroduce into commerce and 50 ppm threshold to conduct research

Initial Commercial Scale Cleaning Trials Unsuccessful

- Bench-scale screening study of eleven commercially available surfactants and three organic solvents for removal of SOCs showed that PCBs can be removed
- Large-scale cleaning/washing experiments using commercially available equipment and aqueous based cleaning solutions were unsuccessful
 - GraPar modified equipment
 - SeKoN centrifuge
 - ALMCO rotary drum washer equipped with a dryer
- Large scale tests using organic solvents and CO₂ achieved reductions to ~10 ppm
 - itec Environmental Group, Inc.
 - Environmental Technology Unlimited
 - Cool Clean Technologies, Inc.

Resolution of Variances in Analytical Procedures

- During these trials, inconsistencies in the analytical results for residual PCB content were revealed---more PCBs after cleaning than before
- A series of control experiments were initiated to develop an understanding of the expected variability of PCB analyses using conventional analytical procedures
- A one day seminar was held in FY 05 with analytical experts from the U.S. and Europe to try to understand the limitations of the state-of-the-art in PCB analysis methods
- A follow up seminar was held in FY 06 to review progress
- The standard analytical techniques used for analyzing plastics are considered adequate

Where are the PCBs?

- The PCBs found in the polymers recovered from shredder residue are in two forms
 - Dissolved in the oils and dirt that are on the plastics
 - Adsorbed on the plastics
- The amount of PCBs adsorbed depends on the type of plastics material and the solubility of the PCBs in the cleaning solution, as well as the process operating conditions
- Suggests that a two-stage process is needed for successful removal of the PCBs

Presently Testing the Following Staged Processes

- ECO2 two-stage
- Vacuum devolatilization (Midland Compounding), second stage
- One other undisclosed compounder, first stage
- Argonne two-stage PCB removal system

ECO2 Plastics Inc. **---PET Recycler**

- ECO2 Plastics, Inc. patented waterless cleaning process
- Process uses a biodegradable solvent and liquid carbon dioxide in a closed-loop system that cleans and reuses the cleaning agents
- Project is 50% complete
- Final deliverables
 - ~300 pounds of clean plastics
 - Mass and energy balance on cleaning process



ECO2's Solvent Wash System



ECO2's CO₂ System

Midland Compounding ---Vacuum Devolatilization in a Twin Screw Extruder

- A compounding, development and testing facility
- Testing on the polyolefins recovered in the Argonne process
 - Water will be added during extrusion
 - Extruded under vacuum
- Testing should begin in April 2008
- Deliverables
 - Material for PCB testing
 - Condensate for PCB testing



Leistriz Twin Screw Extruder

Argonne Two-Stage Process

- Bench-scale tests were conducted at Argonne using a non-flammable organic solvent to clean polyolefin plastics recovered from shredder residue
 - Plastics were washed under conditions (time and temperature) that minimized the absorption of the solvent by the plastics
 - The washed plastics were then treated to desorb the PCBs
- Reproducible results indicated that the PCBs could be removed to a concentration below 2 ppm in the polyolefins using 100 gram samples
- A scaled up two-stage cleaning system (15-25 lb/hr) has been designed

Plans for Next Fiscal Year

- Complete the testing of alternative processes:
 - ECO2 Plastics Inc.
 - Vacuum devolitized (Midland Compounding)
 - One other undisclosed compounder
 - Argonne process

- Develop a conceptual design and perform cost analysis of the competing processes

Summary

- Four processes under development/testing:
 - If successful polymers can be re-used
 - If unsuccessful polymers along with other remaining organics can be used as an alternate fuel such as for a cement kiln operation

Publications

- *Overview of Washing Systems for Commercial Cleaning of Plastics Separated from Automotive Shredder Residue*, Sendijarevic, I.; Sendijarevic, V.; Winslow, G.R.; Duranceau, C.M.; Simon, N.L.; Niemiec, S.F.; and Wheeler, C.S., SAE Paper No. 2005-01-0851.
- *Screening Study to Evaluate Shredder Residue Materials*, Sendijarevec, V., N. Simon, C. Duranceau, G. Winslow, R. Williams, C. Wheeler, S. Niemiec, D. Schomer, SAE Paper No. 2004-01-0468.