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A Report

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The objective of this project is to explore the feasibility of automated sorting of post-consumer plastic bottles by means of incorporating a magnetic marker into the source plastic materials. The proposed method involves introducing small amounts of a magnetic material into samples of different virgin plastic resins. The plastics would then be separated by means of differences in magnetic signal level recorded by a detector.

Presented below is a synopsis of the results of our investigations.

A. Testing of the Hypothesis

We have shown that it is possible to detect very low concentrations of a magnetic material (iron (II) chloride, $FeCl_2$) which has been incorporated into nonmagnetic plastic such as high-density polyethylene (HDPE). $FeCl_2$ at concentrations of about 1% by volume for a sample volume of about 1 cubic centimeter (cc) was detected reliably by our LakeShore commercial magnetic susceptometer. The design of an alternative detector which can be scaled up to accommodate larger objects such as plastic bottles, and which is equally or more sensitive than the susceptometer is a technical problem which we continue to work on. It is our belief, however, that the concept of magnetic separation of post-consumer plastic waste is sound. That being said, there are impediments which hinder the development of our method into viable recycling technology. These impediments were foreseen when the project was conceived, but even though we anticipated them, they still remain formidable to surmount.

First, there is the problem of detector development which was mentioned above. To compete on a commercial scale, the detector must be inexpensive, but very sensitive. These two conflicting requirements make the design process difficult, especially in view of our limited resources.

Second, the marker material that we have chosen, that is, $FeCl_2$, is inorganic and there are already many inorganic additives in colored plastic, especially non-foodstuff containers. Some of these additives also contain iron. We have already measured the background magnetic signal of 120 milligrams of colored plastic and found it to be very small, approximately at the threshold of detection of the susceptometer ($5x10^{-8}$ electromagnetic units). Therefore, even at low concentration levels, the $FeCl_2$ marker would still be readily detectable. However, $FeCl_2$ is colored (though not brightly so) and could have some impact on the overall color of the plastic in which it is dispersed. The intensity of the $FeCl_2$ color as a function of concentration levels will be determined with a

miniature extruder which we developed for this specific purpose. Powdered HDPE plastic which was being solicited from Quantum Chemicals has now been obtained. This phase of the project can now proceed. We have also investigated the possibility of the use of organic magnets as markers, but the properties of these materials are still being studied by researchers. Therefore, their use in this project is not practical at present.

The two problems mentioned in the preceding could probably be more easily overcome if one used a marker that: (1) has a stronger magnetic signal, and (2) is localized in the plastic container instead of being uniformly dispersed. The method would be similar to a book detection system in which hidden magnetic strips can be "sensitized" and desensitized. These states can then be distinguished by a detector which triggers an alarm if one of these states is detected. We have had discussions with the 3M company (St. Paul, MN) which manufactures such detection systems. We illuminate these discussions in part C of this report.

B. Applications

As was mentioned in the previous report, the miniature extruder that we have developed may be useful for instructional and illustration purposes in industrial technology courses. The design still has to be refined in order to maximize its utility.

C. Additional Funding Sources

As alluded to above, we have had initial discussions with the 3M company regarding their interest in magnetism-based automated sorting systems for recycling purposes. Their interest in adapting their technology for use in the recycling industry predates this project. The company remains interested in automated sorting techniques, but is less interested in the use of magnetic markers as the vehicle for the sorting process. The reason is that though a magnetism-based system could be competitively priced, the method is inherently invasive, that is, something has to be added to the object that you are trying to detect. This makes the magnetic method less attractive than optical methods, for example, which necessitate no changes in the processes involved in the manufacture of plastic containers. Also, a localized magnetic source such as a small metal strip could negatively impact recovery and reusability of the plastic. It is therefore apparent that magnetic separation of plastics is not a priority for 3M and funding support is unlikely.

At this point in time, alternative technologies are more versatile, less invasive and more attractive than the methods being used in this project. Though the exploration of this technique has

been, and is worthwhile, its further development and commercialization is not likely in the near future. Of course, new materials are being developed with increasing frequency. We will therefore continue to monitor these developments, with the hope that marker materials with characteristics more suitable for recycling applications can be found.