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# Project Summary

# Evaluation of the Chemical Resistance of Geotextiles, Geonets, and Pipe

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**A technological base was sought for determining the chemical resistance and long-term durability of geotextiles, geonets, and pipe exposed to liquids representative of those in a waste containment facility. A desired end product was to develop and validate generalized test methods assessing the chemical resistance of these products in a laboratory setting. Although the methods have produced valuable information when a high level of expertise has been applied, the fingerprinting techniques do not offer clear-cut means to discriminate subtle differences in polymer structure.**

***This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

The increasing amounts of solid waste being generated as the result of the United States being an industrialized nation are dealt with in many ways—from illegal dumping to incineration. The intermediate practice of landfill disposal has become the method of choice among manufacturers, governments, and the private sector. Unfortunately, the advances in landfill technology have not been able to keep up with the increasing amounts and variety of wastes the landfills are required to isolate. The most significant breakthrough, however, occurred about 10 years ago when synthetic materials (termed geosynthetics) began to compliment natural materials in the construction of disposal sites.

Research on these materials has, thus far, been limited to generating data applicable to the materials' engineering abilities. Data such as ultimate strength, tear resistance, and sheer strength have long been determined for the use of designers and engineers planning the landfill. Although these data are satisfactory for applications such as drainage ditches, reinforced embankments, and paved surfaces they are not sufficient for hazardous waste containment designs. The importance of physical data is not diminished in such cases, but the importance of chemical resistance becomes crucial.

## Project Objectives

The experimental program was intended to provide a means to verify that the proposed generalized test program can, in fact, identify plastic that is unacceptable for the waste chemical to be contained.

Specific objectives were as follows:

- *Recommend tests for geosynthetics*

  Physical testing procedures were chosen from those currently being employed by chemical resistance testing laboratories. Further, analytical testing procedures were chosen from those commonly used in analytical chemical laboratories. The sensitivity of selected test methods to degradation induced by chemical exposure was evaluated.

- *Correlate analytical and mechanical test data*

  Analytical and microstructural data were compared with mechanical index property data to evaluate proposed fingerprinting or equivalency testing procedures. Relationships between physical property and analytical data are required to relate molecular changes to bulk physical property losses. This relationship is essential if such practices are to play a significant role in chemical resistance evaluations.

- *Establish guidelines for evaluation and failure criteria*

  Evaluation of chemical resistance data requires clear understanding of the test methods used and sound judgment to properly distinguish random variability from degradation caused by chemical attack.

## Experimental Procedures

The materials to be tested were selected according to current trends in design and use. The exposure matrix was based on findings of earlier work in these laboratories with an emphasis on inducing failure. These failures are not to occur for the purpose of invalidating the use of geosynthetics, but rather to assess the ability of the proposed immersion procedures and test methods to identify resistance of materials to immersion media. Additionally, analytical tests common to the chemical sciences were employed to monitor changes on a molecular level.

The experiments followed the general guidelines outlined in the EPA's preliminary guidance so that the program would assess the extent to which those procedures would accomplish the intended purpose. This involved a 120-day exposure period; two exposure temperatures (23 and 50 °C); and 30-day property monitoring intervals, in accordance with EPA Method 9090 for geomembranes. It was believed that the chemical resistance program recommendations for textiles, net, and pipe should parallel those already employed for geomembranes. Products representative of the most commonly specified geotextiles, geonet, and pipe were needed to provide an experiment that evaluated materials representative of current industry design practice for waste facility design (Table 1).

Two geotextile products represented the principal classes of nonwoven geotextiles currently available: polyethylene terephthalate (PET) and polypropylene (PP). One product representing each material was tested. Nominal fabric weights were 112 g/m² (3.3 oz/yd²) for PET and 214 g/m² (6.3 oz/yd²) for PP.

Because a survey of the geosynthetics industry indicated that high-density polyethylene (HDPE) is predominantly used in the manufacture of drainage net, one representative HDPE net product was tested.

One smooth interior/profiled exterior HDPE pipe product was tested. Although many diverse kinds of plastic pipe are available in the marketplace and many of these have found application in waste containment facility design, this program did not permit evaluation of multiple products. It was believed that the project objectives could be met by selecting one representative pipe material. Polyethylene pipe was selected because it has been widely used in constructing leachate collection systems.

## Test Selection

We sought index physical property tests consistent with the EPA's interim guidance and representing common, well-accepted standard methods that could be easily reproduced. At the same time, attention was given to evaluating alternative tests, e.g., single-fiber tests for geotextiles and arc bend tests for pipe sections. The requirement of exposing samples in laboratory baths for extended periods of time ruled out tests requiring unusually large or bulky specimens.

Fourier transform infrared spectroscopy (FTIR) was used because it can indicate oxidative degradation and qualitatively characterize polymer surfaces by measuring a wide range of chemical structures. Thermal analysis was applied because of its ability to detect changes in crystallinity of polymeric materials.

As tools for fingerprinting and equivalency testing geosynthetics, the evaluated analytical techniques presented some problems. First, the lack of test standardization and technical documentation hindered efforts to provide consistent, repeatable results. It was necessary to develop individual sampling methods for each material examined. Although the methods employed are by no means definitive, they helped to solve the problems encountered when applying analytical techniques to geosynthetics.

Second, the equipment used is not necessarily representative of that available to other laboratories and manufacturers. Before applying a technique, the limits of each machine must be assessed and then taken into account when interpreting data. Each experiment must be carefully monitored for sources of interference, and experience must be applied to individual methods. Such expertise comes from a learned researcher who is able to apply polymer chemistry in conjunction with analytical instrumentation.

The third consideration is that of interpreting analytical data. The microstructural changes being investigated are very minuscule, and therefore even sensitive methods may provide data that are difficult to interpret (Figure 1).

Presently, the fingerprinting techniques that were evaluated do not offer a clear-cut, readily-applied means to discriminate subtle differences in polymer structure. Further, minute changes in bulk properties cannot yet be detected using analytical methods. Without significant attention to method development, laboratory technique, and interpretation, the development of useful results is difficult. The potential usefulness of these methods should not be discounted since they have already produced valuable information when a high level of expertise has been applied to experimental design and evaluation criteria. With respect to fingerprinting, this project has better defined set-up, test application, and data evaluation problems so that future research will have a more defined approach.

## Outlook

The largest problem now facing wide acceptance and use of fingerprinting techniques is the lack of uniform, repeatable test procedures. The level of accuracy and repeatability remain in question as does the proper interpretation of data. The technology base needs to be expanded so that analytical tests of demonstrated value can be specified with confidence, regardless of who performs the test or interprets the results.

Although some methods (mechanical and analytical) have been identified here as useful, this should not be taken as a complete list. Rather, it should be considered a foundation for further work. Other tests are available to complement those performed here. As geosynthetics experience greater applications in waste containment, such work is needed to fully develop chemical resistance testing.

Analytical testing is believed capable of indicating deterioration before physical methods can, and, therefore, these more sensitive, molecular-level indicators should receive principal attention. For example, the field of reflectance spectroscopy can provide an experienced spectroscopist a wide range of techniques from which to choose; this technology must be further examined. Further, thermal analysis has been shown to indicate degradation both quantitatively and qualitatively; thermal analysis should be continually applied to geosynthetic studies.

***Table 1.*** *Exposure Matrix*

| Geosynthetic Material | Exposure Conditions: Water | Exposure Conditions: $H_2SO_4$ (50%) | Exposure Conditions: $Ca(OH)_2$ | Tests: Physical (replicates) | Tests: Analytical |
|---|---|---|---|---|---|
| Geotextile I (PP*) | -- | 23 °C | -- | Grab Tensile (10) | FTIR† |
| | 50 °C | 50 °C | -- | Mullen Burst (10) | TGA‡ |
| | | | | Permittivity (10) | DSC♦ |
| | | | | Melt Flow Index (3) | |
| | | | | Specific Gravity (3) | |
| Geotextile II (PET**) | -- | -- | 23 °C | Grab Tensile (10) | FTIR† |
| | 50 °C | -- | 50 °C | Mullen Burst (10) | TGA‡ |
| | | | | Permittivity (10) | DSC♦ |
| | | | | Specific Gravity (3) | |
| Geonet (HDPE***) | -- | 23 °C | -- | Transmissivity (2) | FTIR† |
| | 50 °C | 50 °C | -- | Net Compression (3) | TGA‡ |
| | | | | Tensile Strength (3) | DSC♦ |
| | | | | Melt Flow Index (3) | |
| | | | | Gradient Density (3) | |
| Pipe (HDPE***) | -- | 23 °C | -- | Pipe Stiffness (3) | FTIR† |
| | 50 °C | 50 °C | -- | Gradient Density (3) | TGA‡ |
| | | | | Melt Flow Index (3) | DSC♦ |

*Polypropylene; **polyethylene terephthalate; ***high-density polyethylene; †fourier transform infrared spectroscopy; ‡thermogravimetric analysis; ♦differential scanning calorimetry.

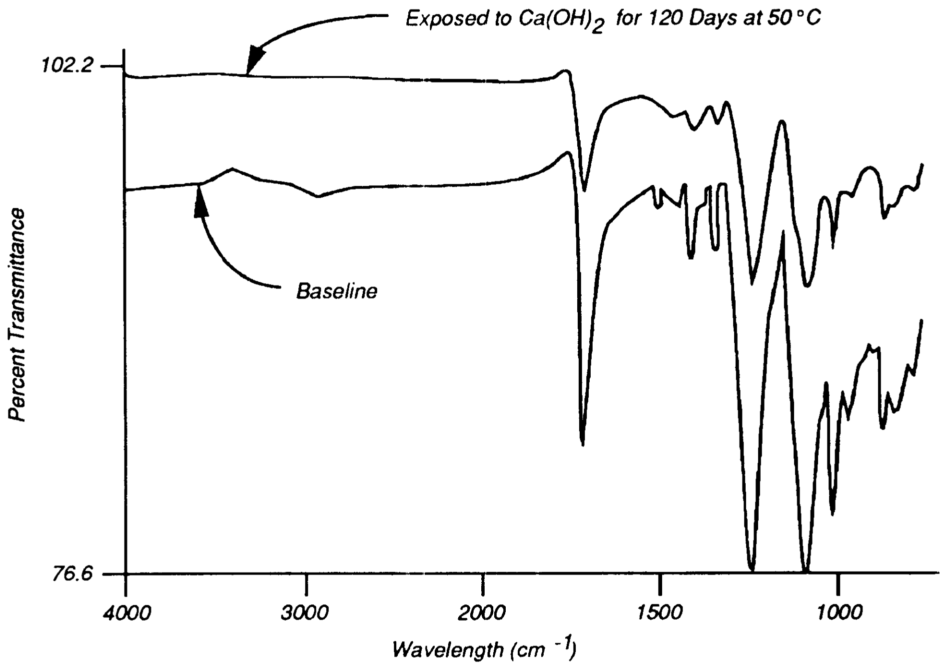


***Figure 1.*** *Fourier transform infrared spectra of polyethylene terephthalate (PET) exposed to base solution (top) and unexposed PET.*



*U.S. Government Printing Office: 1992 — 648-080/60031

Additional analytical techniques to be evaluated include gel permeation chromatography, rheology, nuclear magnetic resonance (NMR) spectroscopy, etc. A broader recommendation is to establish a continuing program of evaluating existing landfill facilities to identify field failures and to assess the condition of installed materials.

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***Robert E. Landreth** is the EPA Project Officer (see below)*
*The complete report, entitled "Evaluation of the Chemical Resistance of Geotextiles, Geonets, and Pipe," (Order No. PB92-170 562/AS; Cost: $19.00, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
*Telephone: 703-487-4650*
*The EPA Project Officer can be contacted at:*
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