PHENIX Note #245

An Investigation of the Reflective Properties of Tyvek Papers and Tetratex PTFE Film

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ABSTRACT

The diffuse reflective properties of Tetratex PTFE film and several types and styles of Tyvek papers were characterized and compared.

Introduction

Highly reflective materials are used to minimize light loss and maximize the light output of scintillating materials in calorimeter type detectors. The reflective characteristics of a material need to be coordinated with the wavelengths of scintillation light produced in the detector, and with the transmission characteristics of any intermediate light collecting or guiding components. The reflective material may be selected to optimize the output of the desired wavelengths of light. Physical characteristics, such as thickness, flexibility, stability, and "handleability" also need to be considered.

Reflectance Measurements

Reflectance was measured as a function of wavelength using an Hitachi model 3210 double-beam spectrophotometer. The spectrophotometer was equipped with a large sample compartment and an integrating sphere to collect the diffuse reflected light. The sphere is 60 mm in diameter and its inside surfaces are coated with barium sulfate. The sphere has five orthogonal 18 mm diameter ports: four in the horizontal x-y plane at 0, 90, 180,

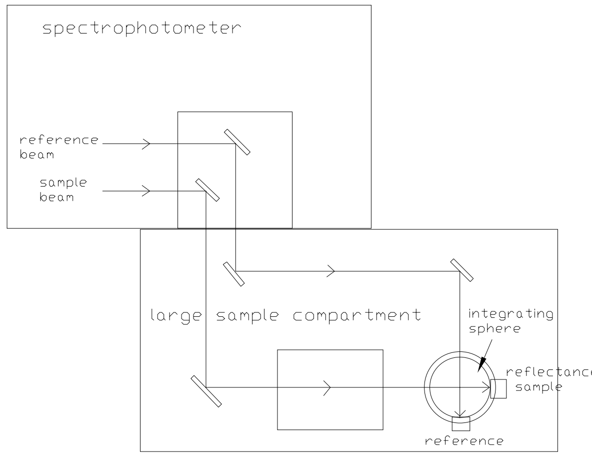

Figure 1: Schematic optics of Hitachi Model U-3210 spectrophotometer with large sample compartment and integrating sphere. (adapted from Hitachi user manual).

and 270 degrees, and one at the bottom in the -z direction. The spectrophotometer measures the ratio of the intensities of two light beams: the reference beam and the sample beam. The sample beam enters the integrating sphere and is diffusely reflected by the sample material held in the port facing the sample beam. The reference beam enters the sphere at an angle of 90 degrees with respect to the sample beam and is diffusely reflected into the sphere by a Spectralon plug, which fits into the port facing the reference beam. Spectralon is a highly reflective, teflon based, diffuse reflecting material manufactured by Labsphere in North Sutton, New Hampshire.

A photomultiplier tube mounted in the bottom (-z) port of the integrating sphere, collects the reflected light. The amount of light reflected by the sample is thus measured relative to the amount reflected by the Spectralon plug. The beams are balanced by measuring two Spectralon plugs prior to sample measurements, thus a Spectralon sample would read as 100% reflectance across the measured spectrum. A layer of opaque black paper was applied behind the sample to eliminate any possible reflection from the sample holder. Figure 1 shows a schematic representation of the spectrophotometer optics. Several papers and reflectors were measured for comparison and as a check of our system. Samples

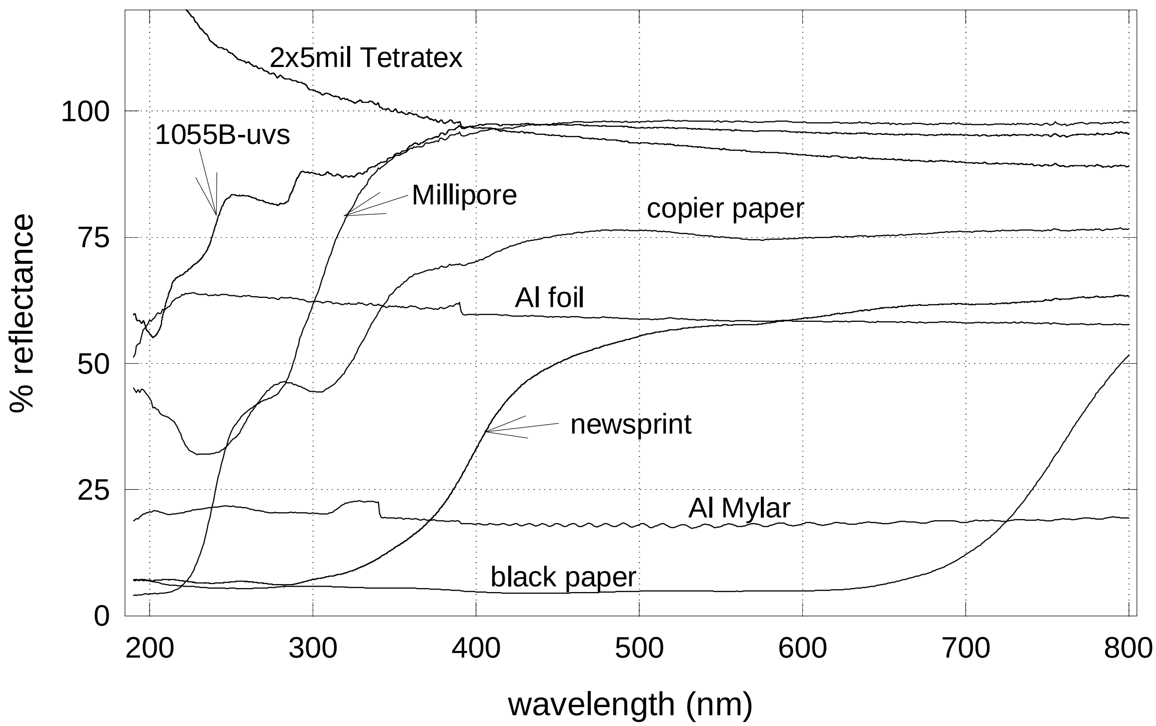

Figure 2: Survey of reflectance measurements.

of copier paper, newsprint, Millipore paper, black paper, aluminum foil, and aluminized Mylar were measured. Data from these measurements are shown in Figure 2.

The reflectance measurements in this study are all made relative to Spectralon. Although the reflectance of Spectralon (as shown in Figure 3) is close to 100% and is almost flat across the observed spectrum, it is not a perfect reflector. The measured "% reflectance" is useful for comparison of different materials, but is not the absolute refectance. A potential flaw in our method is that our system works well with diffuse reflectors, but any specularly reflected light would be reflected back out of the integrating sphere and would be lost. A mirror placed in the sample holder would appear to have a very low reflectance. This effect likely lowered the measured reflectance of the aluminum foil and aluminized Mylar samples measured and displayed in Figure 2. This problem could be overcome by angling the samples relative to the incident beam, but we did not think it necessary for the Tyvek and Tetratex measurements, as they appear to be nearly Lambertian reflectors.

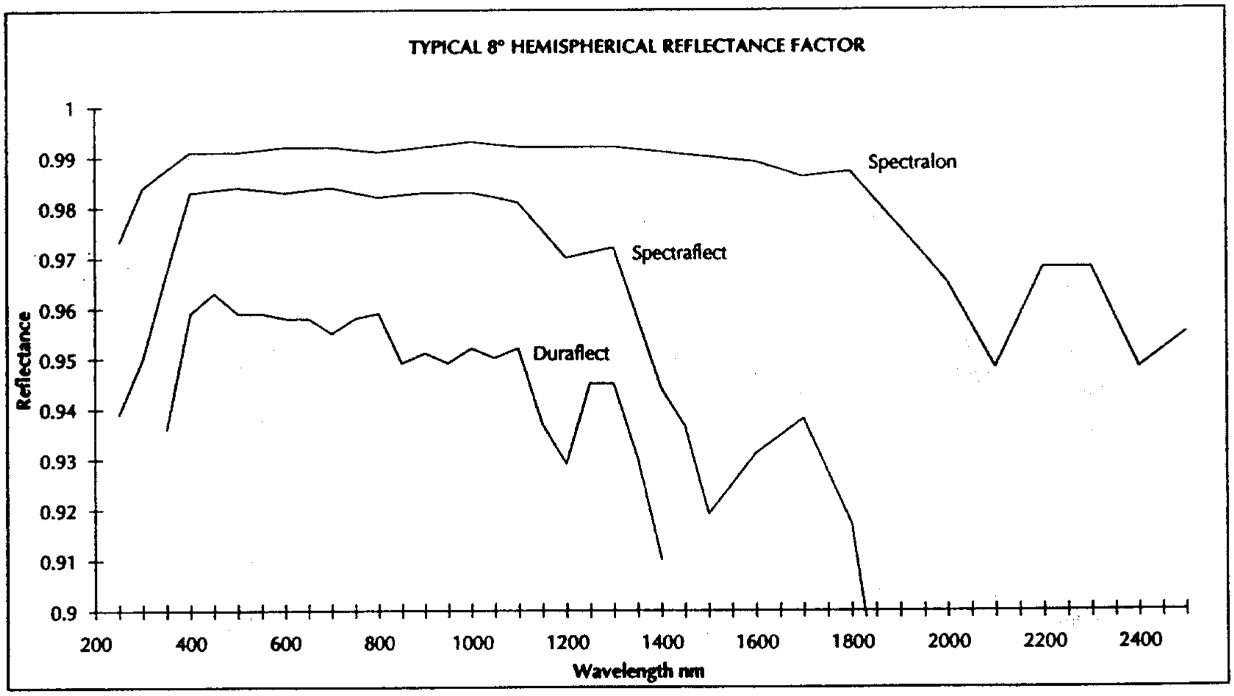

Figure 3: Reflectance of Labsphere Spectralon, Spectraflect, and Duraflect as a function of wavelength.(reproduced from Labsphere 1994-5 catalog, p.2)

Tyvek Papers

Tyvek is a family of spunbonded olefin paper-like products manufactured by Du Pont. Tyvek is made from 0.5-10.0 micrometer high-density polyethylene fibers, which are bonded by heat and pressure, without any other binding agent. We examined three types of Tyvek: Type 10, which is smooth, flat, and paper-like; and Types 14 and 16 which are embossed and more cloth-like. Type 16 is also perforated with 0.25-0.38 mm holes. The samples tested ranged in thickness from 0.13mm to 0.35mm. Tyvek style numbers increase with sheet thickness, so for Type 10, style 1025D was the thinnest and 1085D was the thickest. The samples of the several varieties of Types 10, 14, and 16 that we measured were cut from 2 manufacturer sample books. A few special styles, like the UV stabilized 1456 and 1055B, were acquired separately.

Figure 4 shows the percent reflectance as a function of wavelength curves for several styles of Type 10 Tyvek. Type 10 is two-sided, but no significant difference in reflectance

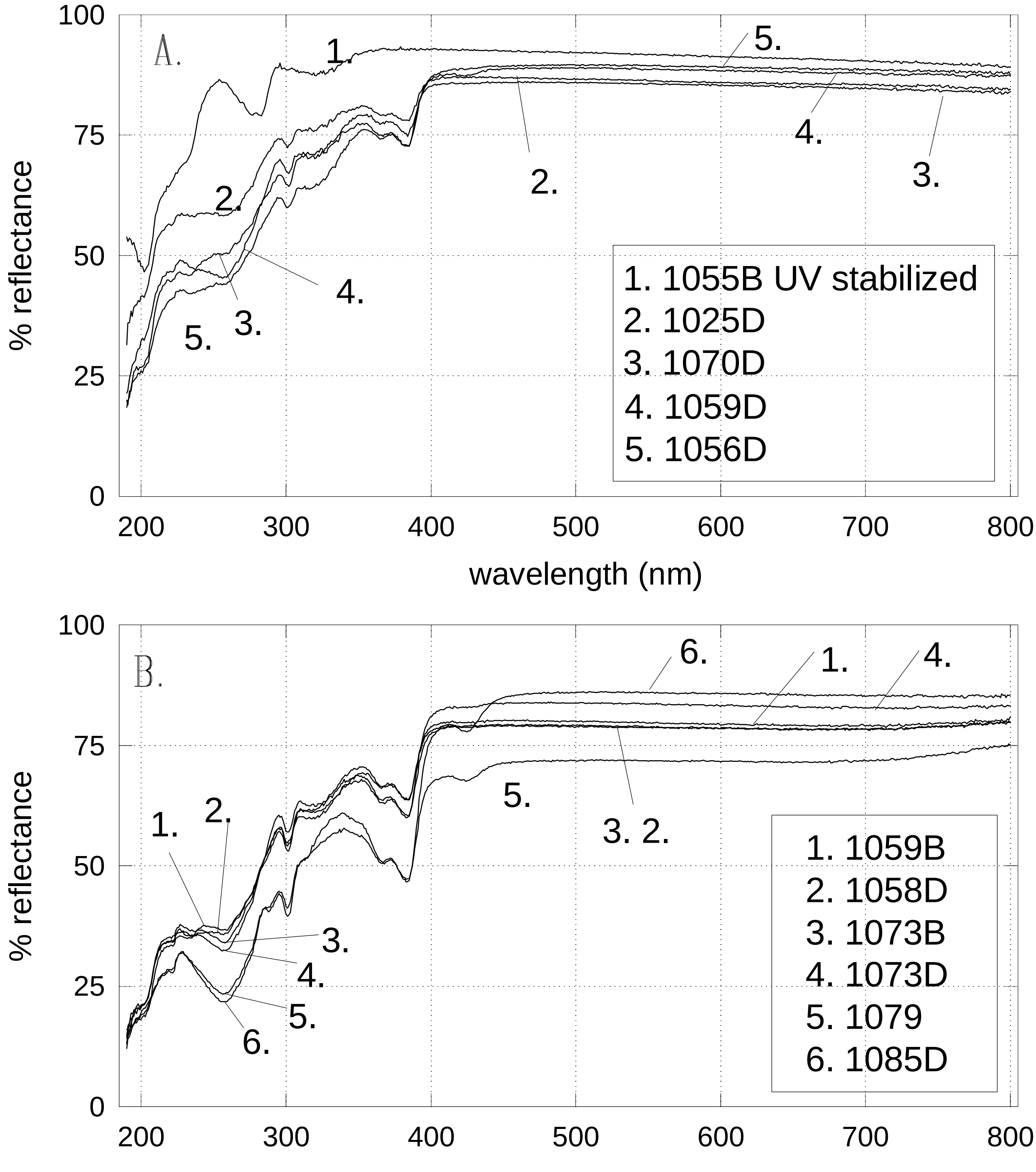

Figure 4: Reflectance measurements, relative to Spectralon, of Tyvek Series 10 papers.

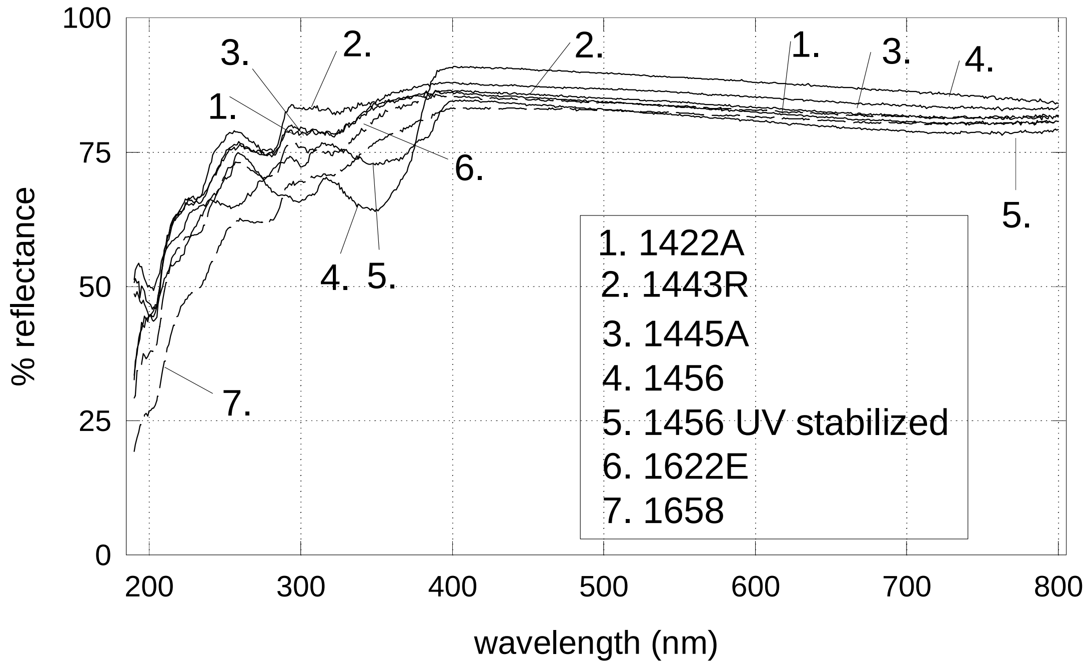

Figure 5: Reflectance measurements, relative to spectralon, of Tyvek Series 14 and Series 16 papers .

was observed between the two sides of any style. Style number 1079 and all style numbers with a "D" suffix are treated with an anti-static agent, and with a corona discharge to oxidize the surface thereby improving the adhesion of inks, coatings, and adhesives. Styles with a "B" suffix are untreated. The degradation of untreated Tyvek surfaces is accelerated with exposure to ultraviolet light, but UV stabilized styles are available. We tested two UV stabilized styles: 1055B(uvs) and 1456(uvs). Both uvs versions improved as UV reflectors relative to their un-stabilized counterparts. Style 1055B(uvs) showed the best overall reflectivity of the Tyvek samples tested, and was therefore selected for use in the PHENIX EM calorimeter.

Reflectance curves for Tyvek types 14 and 16 are shown in Figure 5. Type 14 styles with an "R" suffix and Type 16 styles with an "E" suffix have been corona discharge treated and coated with the same antistatic agent as Type 10 "D" styles. Type 14 styles with an "A" suffix were not corona treated but do contain the anti-static agent.

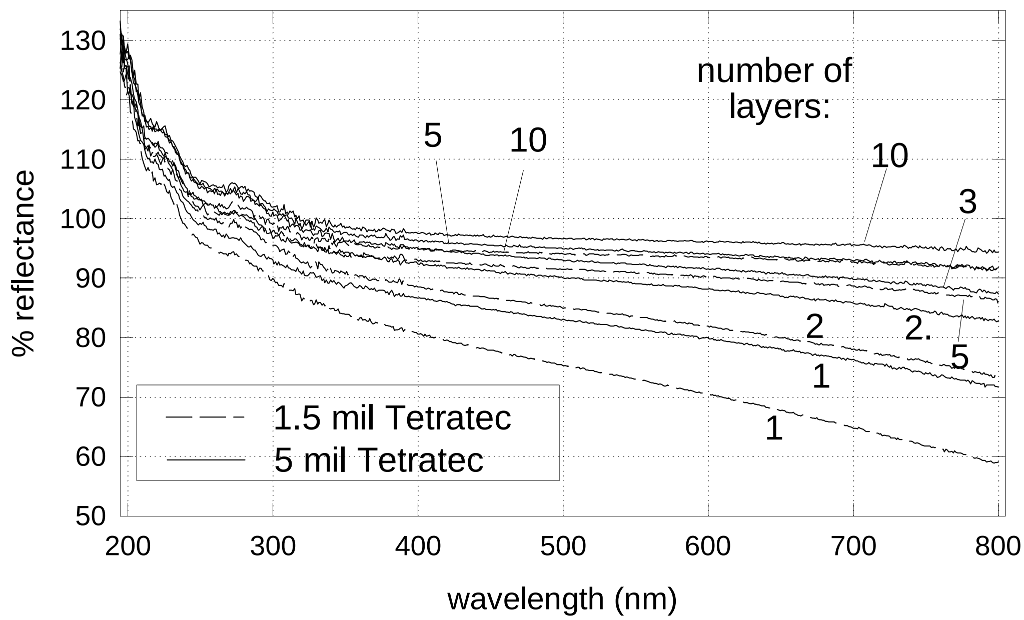

Figure 6: Reflectance of single and multiple layers of 1.5 and 5.0 mil Tetratex "teflon" as a function of wavelength.

Tetratex PTFE "teflon" Film

Tetratex is a porous, polytetrafluoroethylene (PTFE) film, more commonly known as teflon. While Tetratex is manufactured mainly for use as a microporous membrane, it's high UV reflectivity and malleability make it ideal for wrapping crystal scintillators. It also tends to make good optical contact with polished surfaces. The reflectance of Tetratex was measured as a function of film thickness. Measurements were made of single and multiple layers of both 5 mil and 1.5 mil thicknesses. Data from these measurements are plotted in Figure 6.

The % reflectance of the Tetratex is not only dependent on the overall thickness, but also depends upon the number of layers. For instance, 2 layers of 1.5 mil had a higher reflectance than 1 layer of 5 mil. It is probably more desirable to use multiple layers of the thinner material to obtain a more uniform result. Tetratex is easily "bruised", and when locally compressed loses its reflectivity.

1. References

1. Labsphere (North Sutton, NH 03260) "Reflectance Materials" from Spectralon product Catalog. 1994-5.

2. DuPont Tyvek (DuPont Company Nonwovens Wilmington, DE 19880-0705) product information "Tyvek Handbook" and "Physical Properties of Tyvek: Guidelines for Printing on Tyvek".

3. Tetratec Corp. (Feasterville, PA 19053) Product information for Tetratex.