Characterization of the Reflectivity of Various Black and White Materials

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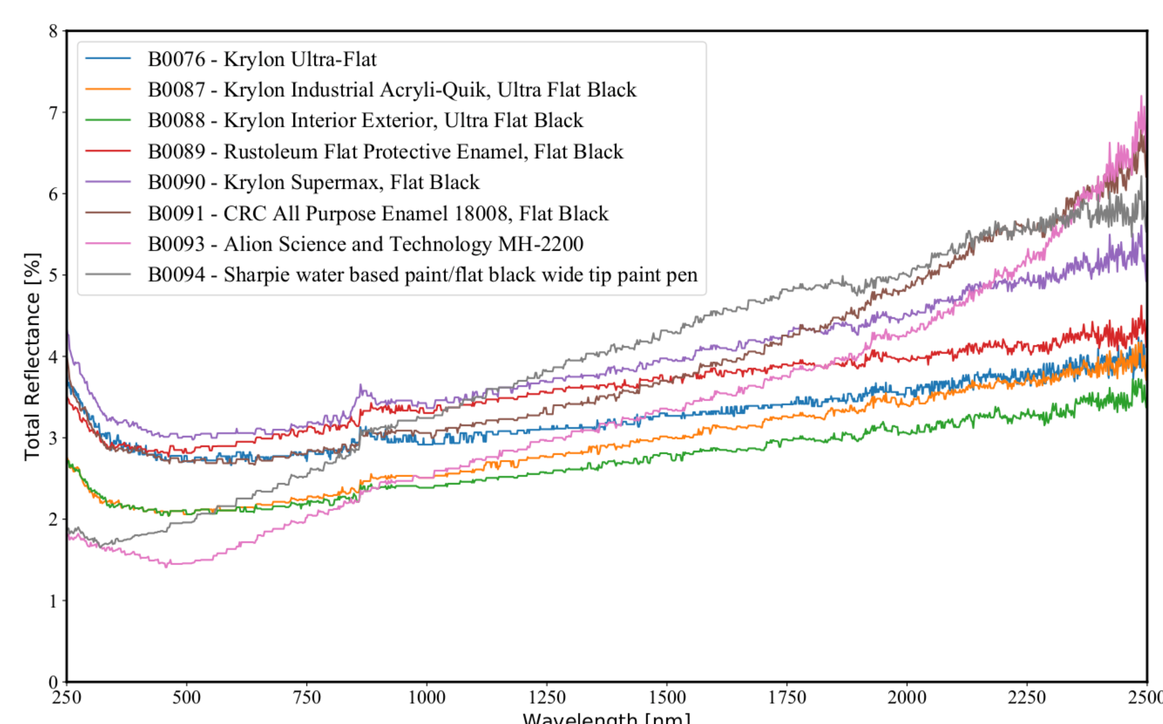
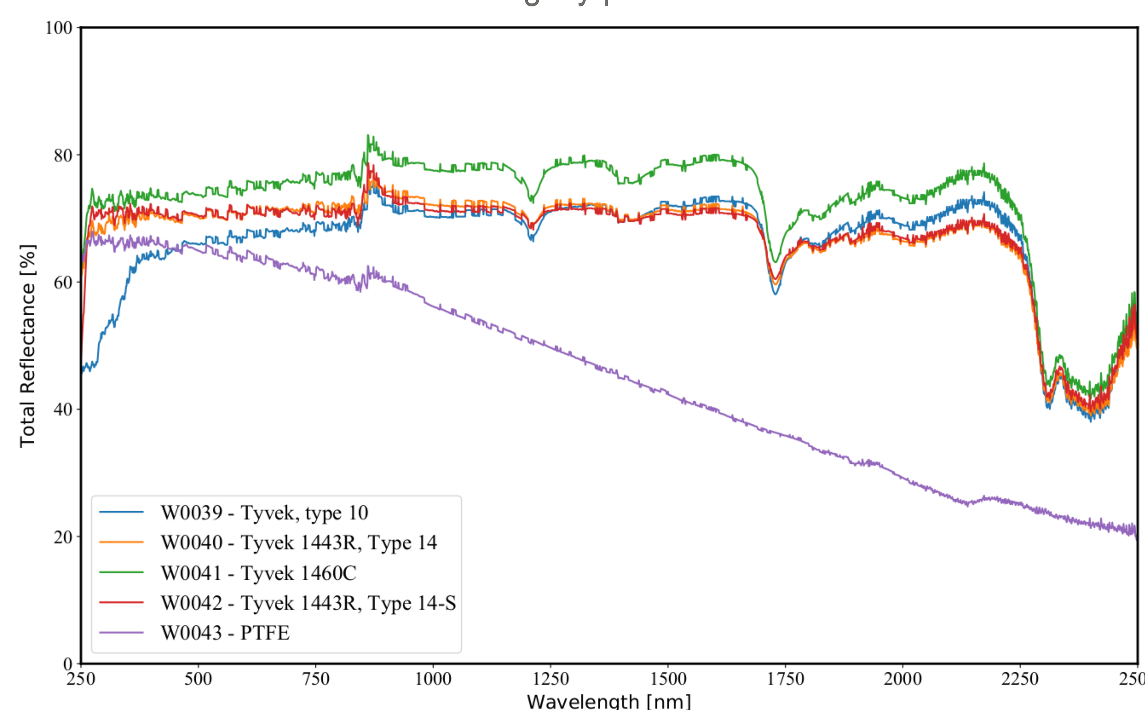


Figure 1. A range of black spray paints were tested (B0076, B0087-91). B0093 was also sprayed, via a single action airbrush.

Figure 2. White materials that may be used as calibration screens. PTFE is best suited for optical applications, where the total reflectance is still relatively high (>60%). The Tyvek (Polyethylene fibers) samples varied in surface finish and several were slightly perforated.



Code	Sample
B0075	Conclarity 2" Black Felt Tape
B0076	Krylon Ultra-Flat
B0077	Nyxlon (wood surface treatment)
B0078	Avery Marks-A-Lot Permanent Marker
B0079	Sharpie Permanent Marker
B0080	Speedball Super Black \#3338 Ink
B0081	Koh-I-Noor Trans.Mix 9065F.BLA Ink
B0082	Rapidograph Ultradraw 3085F.BLA Ink
B0083	Dixon Redimark Permanent Marker
B0084	Metron Solvent Resist Ink
B0085	Metron Permanent Ink
B0086	Ground glass slide with black anodized Aluminum backing
B0087	Krylon Industrial Acryli-Quik, Ultra Flat Black
B0088	Krylon Interior Exterior, Ultra Flat Black
B0089	Rustoleum Flat Protective Enamel, Flat Black
B0090	Krylon Supermax, Flat Black
B0091	CRC All Purpose Enamel 18008, Flat Black
B0092	Black Anodized Aluminum - Backer for B0086
B0093	Alion Science and Technology MH-2200
B0094	Sharpie water-based paint/flat black wide tip paint pen
W0039	Tyvek Solid Fabric type 10, McMaster Carr part 1650T21
W0040	Tyvek #1070 1443R STYLE Type 14, www.questoutfitters.com
W0041	Tyvek #1071 1460C STYLE, www.questoutfitters.com
W0042	Tyvek #1075 1443R STYLE Type 14-S (metallized), www.questoutfitters.com
W0043	Polytetrafluoroethylene (PTFE) sheet

Table 1. List of materials.

ABSTRACT

We report on an expanded catalog of total reflectance measurements of various common (and uncommon) materials used in the construction and/or baffling of optical systems. Total reflectance is measured over a broad wavelength range (250 nm < λ < 2500 nm) that is applicable to ultraviolet, visible, and near-infrared instrumentation.

INTRODUCTION

Maximizing the sensitivity of any optical or infrared astronomical instrument requires careful consideration of stray and scattered light within. Minimization of these unwanted reflections and scattering can be accomplished via baffles, material surface finishes, and coatings. In the first several papers of this series[1,2,3], a broad range of black materials and coatings were tested. We now report on an expanded set of samples. The total reflectivity measurements are relevant to ultraviolet, optical, and near-infrared instrumentation (250 nm < λ < 2500 nm). Updates to the project website (https://instrumentation.tamu.edu/instruments/reflectance/) including downloadable data files and interactive plots are in progress.

TOTAL REFLECTANCE MEASUREMENTS

Texas A&M University maintains a Materials Characterization Facility (MCF) that includes a wide range of instrumentation for investigating material properties. We used the Hitachi High-Tech U-4100 UV-Visible-NIR Spectrophotometer and obtained reflectance profiles for the samples. With this system we measured precise reflectance values at each wavelength (in 1 or 2 nm steps) for the wavelength range 250 nm< λ <2500 nm. Figure 6 shows the instrumental setup of the spectrophotometer. The reference and test sample are placed in the 6 o'clock and 3 o'clock positions of the integrating sphere, respectively. The data acquisition procedure involves obtaining a baseline measurement at each wavelength of the reference $BaSO_4$ wafers (~100% reflectance) in both the reference and sample slots of the dual beam spectrophotometer. We then measure a second reference sample having 5% reflectivity (Labsphere SRS-05) and measure the reflectivity of the test sample. We compare the 5% reflectance reference sample to the values provided by the manufacturer and use this ratio to construct the absolute reflectivity of the test sample as a function of wavelength. During each day of testing the SRS-05 standard is measured to ensure measurements from different test days are tied to a common reference. The U-4100 changes detectors at 850 nm, which is likely the cause of the small features visible in most material scans near this wavelength.

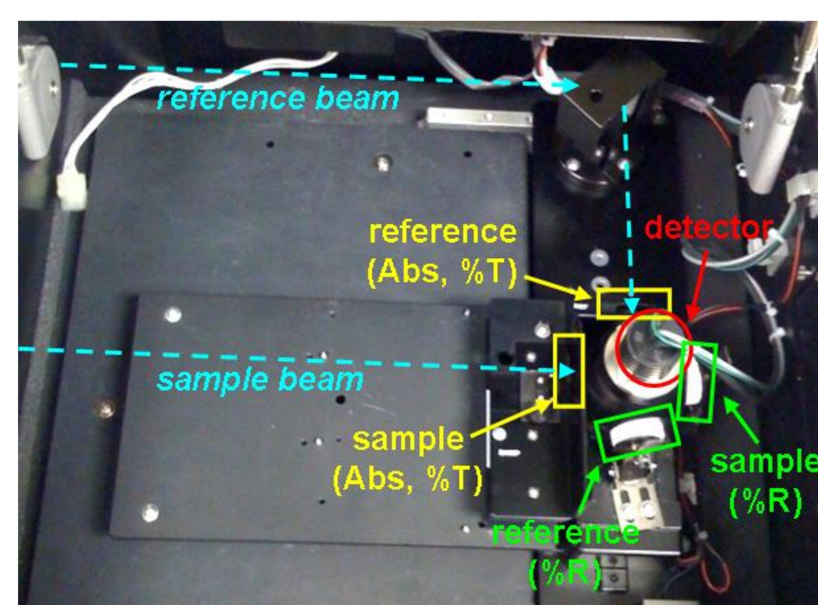


Figure 6. Internal view of the U-4100 UV-Visible-NIR Spectrophotometer. Test samples are placed at the 3 o'clock position (sample %R)

CONCLUSION

We have presented additional total reflectance measurements of various materials that have been —or may be—used to minimize stray and scattered light within optical and near-infrared astronomical instruments. Control of stray light within an instrument is an important concern and the material choice and surface treatment within the instrument requires careful consideration. Information about the samples including reflectivity plots and text files of the calibrated data will be made available at https://instrumentation.tamu.edu/instruments/reflectance/. The same page includes information on how to suggest or submit a sample for testing. Due to resource availability no guarantee is made on sample testing turn around time and results will be made public on our website. We are also unable to return any samples that are submitted for testing.

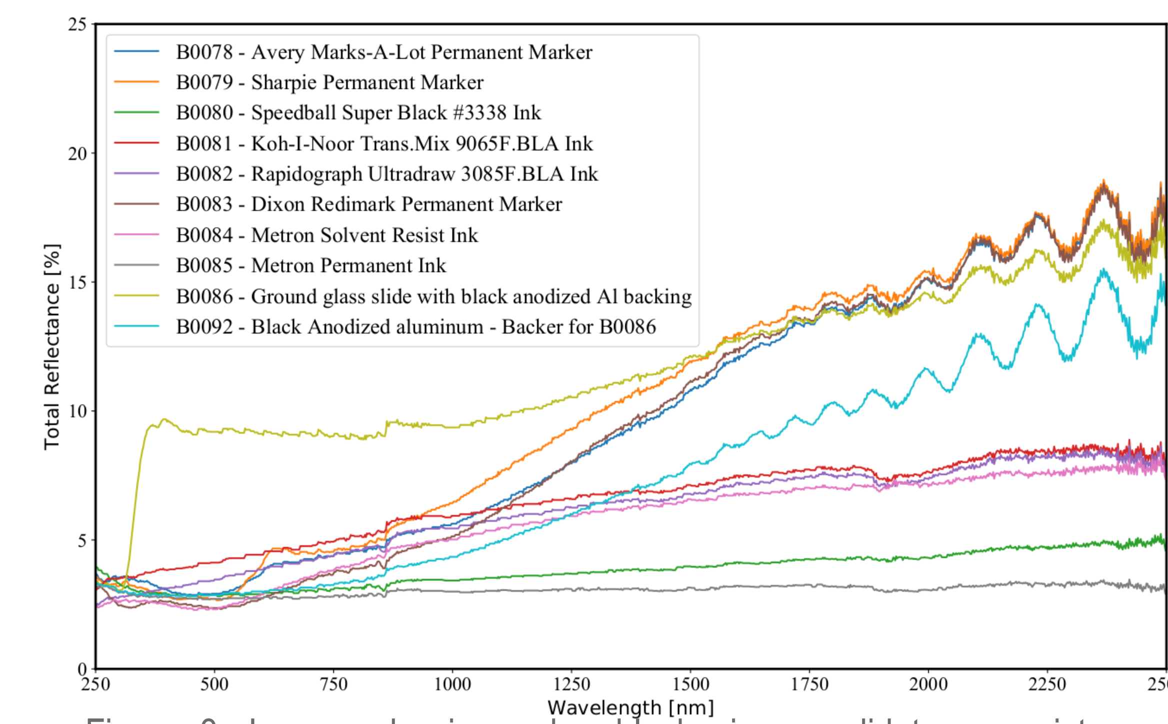


Figure 3. Lens and prism edge blackening candidates, a mixture of permanent markers, India inks and industrial marking inks. The cyclical variability seen in B0092 as well as all of the permanent marker samples starting around 1500nm is an artifact of the particular piece of anodized Aluminum which was slightly visible through the permanent marker.

Both B0081 and B0082 were more difficult to apply evenly and had a glossy finish. B0080 dried quickly with a matte finish. The Metron permanent ink performs very well. The stock viscosity results in a thick coating, however it is possible to thin with water.

Figure 4. Other black materials, including black felt tape and a wood substrate with black surface treatment (Nyxlon).

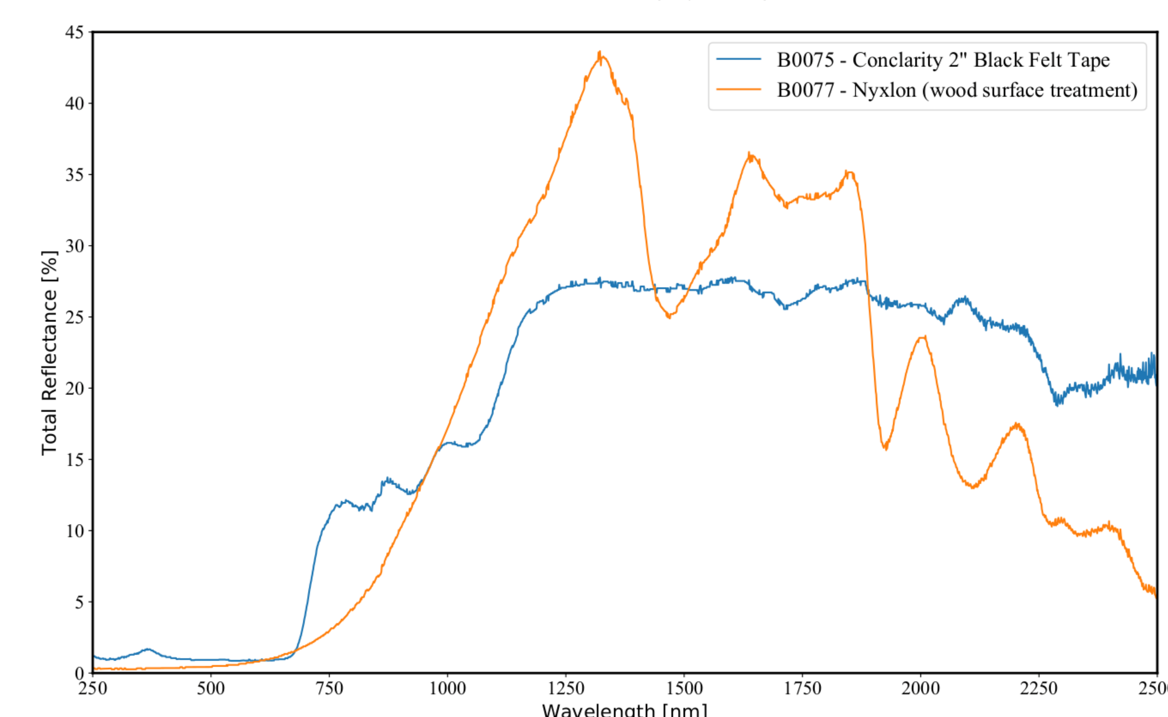


Figure 5. The Metron inks are available with self cleaning precision applicators, or in larger quantities (quarts, gallons, etc.)

[1]Marshall et al. 2014, Proc. SPIE, 9147
[2]Schmidt et al. 2018, Proc. SPIE 10706-195
[3]Schmidt et al. 2018, Proc. SPIE 10706-196

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Acknowledgments

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