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THE ROLE OF THE PETROGRAPHIC MICROSCOPE IN CRIMINAL INVESTIGATIONS

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There are many instances when it is not possible to completely solve problems involving the analysis of substances by either chemical or spectrographic means. In such cases the determination of the index of refraction and other optical properties by means of the petrographic microscope may prove of value. (The index of refraction is an optical property characteristic of any particular crystalline substance, and it is measured by the velocity with which light is transmitted through that substance, as compared with the velocity of light in a vacuum.)

This type of microscope is designed for the specific purpose of studying the optical properties of crystals. The principal difference between its construction and that of the ordinary compound microscope is that in the petrographic microscope there are two Nicol prisms,[1] one (known as the polarizer) below the object stage and the second (known as the analyzer) above the objective. The purpose of the lower one is to plane polarize the light which passes through the microscope.[2] The second prism, in combination with the polarizer, is utilized to determine the optical properties of the crystal being studied.[3]

While the applications of the petrographic microscope are extensive, probably its most frequent use is found in studies of the refractive index of glass fragments picked up at crime scenes, and of abrasives which have been used in sabotage cases.

Case Illustrations

In a certain hit-and-run case[4] samples of a broken headlight lens and one lens of a pair of colored sun glasses were picked up at the scene of the accident. These samples, together with fragments of a headlight lens and colored sun glasses (removed from the running board of the suspected automobile) were submitted for study. Both

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1 A Nicol prism consists of natural, clear, transparent calcite (Iceland or double spar), which has been cut and polished in a definite orientation.

2 Ordinary or non-polarized light consists of a series of wave impulses which are vibrating in a plane normal to the direction of transmission or propagation. These planes of vibration, however, are not in a fixed position but constantly vary. In the case of plane polarized light the planes of vibration in which the wave impulses travel remain in a fixed position parallel to one another.

3 For a concise description of the petrographic microscope and its use see: Kraus, E. H., Hunt, W. F., and Ramsdell, L. S., Mineralogy (3d ed.), Chap. XI: 114-142 (1936).

4 The information regarding this case was called to the attention of the author by Dr. H. F. Vieweg in the course of personal correspondence.

fragments of headlight lens (i.e., the piece picked up at the scene of the crime and the piece taken from the running board) had the same refractive index value (1.507) and the same specific gravity (2.457). The two sunglass fragments likewise had identical refractive indices (1.521), and their specific gravities agreed within the limit of error (2.517 and 2.518, respectively). The results of this comparison afforded a very strong indication, therefore, that the various glass specimens were probably from the same original source.

Research, especially with various types of glass, indicates the danger of forming too hasty a decision based solely upon the index of refraction.[5] There are times when it will yield a definite answer, as where there is a difference in refractive index, but in other instances—as in the following described case—it is advisable to make other examinations as well.

The author had occasion several years ago to compare fragments of glass from a broken automobile window with those picked up along the highway. The results of refractive index measurements on all the specimens submitted, *including several obviously extraneous fragments,* were identical within the error of measurement. In this instance, of course, the petrographer could make no decision of legal value based solely on refractive index. However, another microscope study may be resorted to: namely, the measurement of the amount of light transmission of the glass.[6] These data, together with thickness measurements, enable the petrographer to eliminate the extraneous fragments and thus to reconstruct a portion of the questionable window glass in jig-saw fashion.

In a case of suspected sabotage in which a brake shoe, a drum, and a cable were damaged, a portion of the shoe and some of the cuttings were submitted for study. It was suspected that someone had thrown silicon carbide between the shoe and the cable. The loose cuttings were found to be coated with carbonaceous material, so a portion of the sample was shaken with carbon tetrachloride to clean the surfaces of the larger grains. The solution was filtered off and the residue was separated into a magnetic and non-magnetic portion. The magnetic material, abraded from the cable, constituted about 90% by weight of the sample. The non-magnetic material consisted principally of blue fragments, subsequently identified as silicon carbide, together with a small proportion of

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[5] An examination of the data found in the following papers is the basis of this statement. Morey, G. W., and Merwin, H. E. "The Relation Between the Composition and the Density and the Optical Properties of Glass. I. "The Soda-Lime-Silica Glasses." Jr. Opt. Soc. Amer. *22*:632-662 (1932). Wright, F. E. "The Manufacture of Optical Glass and Optical Systems." Ord. Dept., Doc. No. 2037 (1921). Geller, R. F., and Bunting, E. N. "The System K^2O-PbO-SiO^2." Jr. Res., Natl. Bur. Stand. *17* (2) (1936). Faust, G. T. "Refractive Index Measurements of Some Early American Glasses." Antiques *32* (6):310-312 (1937).

[6] One method of measuring the transmission of light would be the use of a Lange ocular photocell, together with the appropriate Jena glass filters, in place of the regular microscope ocular. A description of the Lange ocular photocell appeared in the catalogue of Pfalz and Bauer, Inc., Empire State Bldg., New York City.

miscellaneous unidentified material. The silicon carbide was identified by means of its characteristic optical properties: uniaxial positive figure,[7] very high index of refraction, partial hexagonal outline of the broken grains, and the pleochroic[8] character of the grains in various intensities of blue. The grains varied in size from 0.24 x 0.18 mm. to 0.46 x 0.30 mm., or approximately a grain size of No. 60 and a U. S. screen size about No. 40 (420 microns). The results of the microscopic study proved conclusively that silicon carbide had been thrown between the brake shoe and the cable.

Another interesting case in which the petrographic microscope offered a distinct solution involved a broken grinding wheel. An injured workman alleged that the emery wheel which broke and struck him was of a certain manufacturer's product. The wheel was submitted for petrographic study, together with samples of Turkish and Grecian emery ores. A sample of the unknown wheel was treated with a 0.5% sodium hydroxide solution to remove the bond. This sample was then separated into several fractions on the basis of the respective specific gravities. The results of the analysis revealed emery (80%) and sand (20%). The color of the questioned emery viewed megascopically was black, and in this respect the unknown resembled the sample of Turkish emery rather than the Grecian material. Under the microscope, however, all three samples (the unknown, the Turkish emery, and the Grecian emery) were quite similar. In comparing the optical properties of the three specimens, it was found that the unknown resembled the Turkish emery more closely than the other. The sand fraction consisted almost entirely of quartz, but an occasional grain of emery was observed. On the basis of the petrographic examinations it was possible to offer conclusive evidence which showed that the composition of the broken wheel was not the same as that of the products of the manufacturer being sued.

Other Possible Applications

The above illustrations represent only a few of the manifold possibilities offered by petrographic examination of materials associated with criminal offenses. Further value for such examination is found in problems in which it is necessary to differentiate between solid solutions, double salts, and mechanical mixtures. Also, chemists or spectrographers are unable to positively identify polymorphic substances, such as for example, calcite and aragonite, which compounds are fairly common in industrial and natural products.[9] However, identification of all such crystals can be made by means of their optical properties as determined by the petrographic microscope.

[7] Uniaxial crystals have the property of causing a ray of light to be split into two rays, known as the ordinary ray and the extraordinary ray. If the index of refraction of the ordinary ray is less than the index of refraction of the extraordinary ray the crystal is denoted as being uniaxial positive.

[8] Pleochroism is the property of some crystals to exhibit different colors when light transverses them in different directions.

[9] Smith, M. L. "The Influence of Particle Size, Shape, Aggregation, and Hardness on the Abrasiveness of Fine Powders." Jr. Soc. Chem. Ind. 75:269-275 (1935).