Journal of Criminal Law and Criminology

Volume 32 | Issue 1 Article 14

1941

Microdetermination of Specific Gravity in Forensic Chemistry

Paul L. Kirk

Robert Russel

MICRODETERMINATION OF SPECIFIC GRAVITY IN FORENSIC CHEMISTRY*

Paul L. Kirk† and Robert Russel§

Small fragments of glass frequently serve as evidence in criminal cases because of the frequency with which glass is broken in burglaries, in collisions involving automobiles, and, to a lesser extent, in many crimes of violence. The determination as to whether the glass found, for example, in the clothing of the suspect, originated from glass broken during the commission of the crime is obviously a matter of importance in criminal investigation. Analogous situations will arise with respect to minute fragments of many materials other than glass and, for all of these, the absolute determination or the comparison of specific gravities is an excellent aid in establishing identity or nonidentity of the evidence. In the case of glass, as well as other transparent materials, optical properties, such as refractive index, dispersion, and, for anisotropic materials, their behavior with polarized light, are also invaluable in establishing identity. Absolute proof of identity of glass depends on a knowledge of refractive index, dispersion, and specific gravity, the combined data yielding approximate chemical compositions as well. (1)

Many methods are available for determination of specific gravity of relatively large amounts of solid material. Micro methods have been described by numerous investigators for the determination of density of small amounts of solids. These have been well discussed by Blank and Willard (2) who advance methods of their own. It is interesting that these authors mentioned but did not study the procedure which is described here as being the simplest method of sufficient accuracy which is applicable to the smallest amounts of solid. Both Merwin (3) and Graham (4) have described methods somewhat similar to the one discussed here, but it is believed that criminal investigators have not used these procedures to any extent, possibly due to lack of familiarity with them.

The method consists essentially in balancing the specific gravity of a liquid mixture to that of the glass or other fragment and determining, by means of a small pycnometer, the density of the equilibrium mixture of liquids.

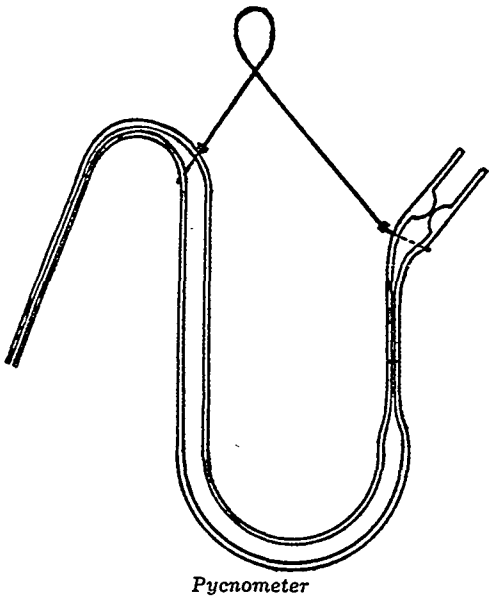
Procedure

The glass or other solid fragment is placed in a micro tube having a capacity of about 1 ml. to which were added a few drops of heavy liquid such as methylene iodide. A fragment heavier than the heaviest available liquid would not be determinable by this

* This paper was prepared with the aid of a grant from the Research Board of the University of California.

† Associate Professor of Biochemistry, University of California.
§ A.B. in Chemistry (1941), University of California.

procedure, but very few glasses have densities greater than that of methylene iodide (3.25 at 20° C.). Heavier liquids with densities as high as 5.2 are available (5), but must be used with appropriate diluting liquids. Since these expedients are rarely necessary, the reference quoted may be consulted for details. To the heavy liquid on which the glass is floating is gradually added a little of the lighter liquid with stirring and with careful observation after each addition. As indicated, most glass which will be encountered will be easily determinable in a mixture of methylene iodide with either chloroform, nitrobenzene, or kerosene. Either the glass tends to float somewhere in the body of the solution, or it will alternately float and sink with mixtures of small alternate portions of the light and heavy liquids. When the density of the liquid is adjusted accurately to that of the solid fragment, a small pipette type pycnometer is inserted and filled with the liquid weighed. Several forms of pycnometers may be used—that shown in the accompanying illustration having been found quite convenient in this investigation. The capacity may be adjusted to any convenient volume, though usually approximately 0.5 ml. is convenient and sufficiently accurate. The instrument shown has no provision other than constrictions for preventing evaporation. If high accuracy is necessary, it must be constructed with small glass caps or other devices to prevent this error, or corrections for the error must be made (6). The pycnometer must be carefully calibrated by weighing it both



Pycnometer
(Illustration approximately 1½ actual size)

empty and filled with water at a measured temperature, preferably that of the liquid used.

The results of measuring numerous glass samples have shown that the ordinary capillary pycnometer does not determine the density of the liquid with as great precision as that obtained in balancing the solid fragment in the liquid mixture. The limiting factor in the accuracy is then the determination of the weight of the liquid in the pycnometer.

Discussion

According to the tables of Winchell (1), the specific gravity of glass will usually fall within the limits of 2.1 to 6.3, with the exception of a very few lead and thallium glasses. The practical top limit of specific gravity of common glasses may be considered to be only about 4.0. Window glass and crown glass, commonly used for spectacle lenses, will usually be in the range of 2.3 to

3.5; while flint glass, also used in lenses and other optical devices, will usually have a somewhat higher specific gravity. In either case, it is possible by this method to obtain significant figures in the fourth decimal and to make the third decimal exact. Considerably greater precision than this may be attained in the comparison of two samples, or an unknown and known, by placing both of them in the flotation liquid at the same time and observing if they behave identically in the same liquid mixture. Since the usual situation in criminal investigation involves comparison rather than absolute determination, it is both rapid and accurate to make such comparisons in this manner.

Numerous other possible methods might be used including the volumetric measurement of the liquids added to the equilibrium mixture; the use of the dilatometer; the volumenometer; or even the Archimedes method. It must be noted that nearly all of these methods require an amount of solid larger than a mere visible fragment or they are difficult in operation. In the latter category is the very sensitive method utilized by Linderstom-Lang (7) for an entirely different purpose. That method, while very accurate, involves the use of a comparatively complicated apparatus, a set of accurate standards, and accurate temperature control. The volumetric measurement of the liquids used in adjusting an equilibrium flotation mixture might seem simpler than the pycnometric density determination recommended. It suffers, however, from the serious difficulty of measuring both viscous and non-viscous; volatile and non-volatile liquids which must be mixed. Drainage errors are in this case large and volumes small, making large errors probable. The method described here may be used for occasional determinations without the purchase of elaborate equipment, and with a satisfactory accuracy for the practical purposes of the criminologist.

References

1. Winchell, A. N., *Microscopic Characters of Artificial Minerals* (Wiley, New York, 1931).
2. Blank, E. W. and Willard, M. L., "Microdensity Determination of Solids and Liquids," *J. Chem. Edu. 10:* 109 (1933).
3. Merwin, H. E., "Method for Determining the Density of Certain Solids by means of Rohrbach's Solution Having a Standard Refractive Index," *J. Wash. Acad. Sci. 1:* 52 (1910).
4. Graham, R. P. D., "The Determination of Specific Gravity of Mineral Fragments by Heavy Liquids," *Trans. Roy. Soc. Canada 2:* 51 (1917).
5. Lange, N. A., *Handbook of Chemistry,* (Handbook Publishers, Sandusky, O. 1937).
6. Damerell, V. R., "A Micro Method for the Determination of Surface Tension and Density," *J. Am. Chem. Soc. 49:* 2988 (1927).
7. Linderstrom-Lang, K. and Lanz, H. Jr., "Enzymic Histochemistry XXIX. Dilatometric Microestimation of Peptidase Activity," *Mikrochem, Acta 3:* 210 (1938).