THE APPLICATION OF RADIANT HEATING IN THE CLINICAL LABORATORY

BY

RAYMOND F. JONES

From the Central Middlesex Hospital, London

(RECEIVED FOR PUBLICATION OCTOBER 12, 1954)

Since Priestley utilized the radiant energy of the sun with his burning glass in his famous experiment of 1774, the method has fallen into disuse and the chemist has accepted the water-bath, the hot-air oven, and the furnace as the standard tools for evaporation, drying, and combustion.

The boiling water-bath is used for evaporating solutions or drying solids which decompose at temperatures slightly above 100° C. It is slow; it wastes nearly all of the energy used; it requires a constant supply of cold water and a constant overflow into a sink; and steam condenses on every available cold surface and helps metals to corrode or wood to rot. If it is used for evaporating volatile solvents, they readily superheat so that loss is often caused by bumping. If gas heating is used for evaporating inflammable solvents, there is a serious hazard of fire, while electrically heated baths have a fairly short life and are expensive.

Drying ovens, often jacketed by steam or toluene vapour, are inefficient because they depend on conduction and convection to transfer heat from the walls of the chamber to an object which is maintained at almost the same temperature. Provision for the removal of vapour is rarely adequate, and the ovens corrode rapidly.

Many of the objections to the drying oven apply to the furnace, but since the furnace is usually well lagged it is more efficient. The main disadvantages are its bulk, high cost, and high energy consumption.

Radiant energy is widely used in industry. It travels in straight lines and is converted into heat when it strikes and is absorbed by an object. We have used it to evaporate to dryness aqueous solutions; to evaporate inflammable solvents; to dry solids without overheating; and to ash stools and other organic material. We have found that our methods employing radiant energy are cheaper, quicker, and more convenient than the conventional methods. In particular, in dealing with inflammable solvents, the hazard of fire is obviated and the danger of loss by bumping is eliminated.

Technique

The source of radiant energy is the G.E.C. 250-watt infra-red reflector lamp, which includes an un-tarnishable reflector and produces a roughly parallel beam of radiant energy with maximum intensity at a wavelength of about 1.2 μ. Ordinary glass is transparent to this radiation, and polished metals reflect at least three-quarters of it. In order to make maximum use of the energy for evaporating solvents, heat-absorbing bodies must be placed inside the vessel containing the solvent, and material to be ashed should be placed in a tarnished crucible made of a metal such as nickel. This lamp is screwed into its holder and held in a clamp so that it points vertically downwards on to a sheet of asbestos.

Evaporation of Urine and Aqueous Solutions.—The liquid is placed in a nickel dish, or, with less efficiency, in a porcelain dish. The lamp is directed vertically on to the surface from a distance of about 6 in., and the liquid evaporates quietly, 25 ml. of water requiring about 30 minutes' exposure.

Drying of Stools and Similar Solids.—This can be done in a manner similar to the evaporation of urine, the solid being spread out in a thin layer to keep the surface at a maximum. It is better to spread the stool over a porcelain boat which is slid into a wide glass tube through which a slow stream of air is drawn, removing water vapour and smells, and thus making a fume cupboard unnecessary. A standard "quickfit" socket, SRB29, on a tube 140 mm. long and of 30 mm. lumen is suitable. Suction can be applied through a "quickfit" cone to rubber tubing adaptor MF10/4 (B29 cone to straight glass tube). We use a Royal Worcester porcelain drying boat 100 mm. long, 18 mm. wide, and 10 mm. deep. A rectangular piece of polished aluminium, 9 × 6 in., curved about its short axis so that it forms part of a cylinder with a radius of about 4 in., is placed on the bench beneath the tube so that the tube lies along the axis of the partial cylinder. This serves to protect the bench and to reflect on to the tube energy which would otherwise be lost (Fig. 1).
apparatus and its surroundings are never heated above the boiling point of the liquid.

**Ashing of Organic Material.**—If the radiant energy from an infra-red lamp is directed axially into a parabolic reflector obtained from a large automobile headlight, it is concentrated at the focal point of the mirror and an absorbing object placed there becomes very hot.

The apparatus used consists of a nickel-plated copper sleeve and flange which fits into the recess at the periphery of the reflector. A nickel crucible is held on a wire ring fixed to a brass rod which passes through the aperture at the centre of the reflector. Lead chloride placed inside the crucible melts in about two minutes (temperature 501°C.), lithium carbonate fuses in about 10 minutes (temperature 618°C.), and the maximum attainable temperature with our apparatus is about 650°C., which is reached in 15 to 20 minutes. One gram of dried faeces yields a pale grey ash in 20 to 45 minutes, according to the fat content.

**Evaporation of Inflammable Solvents.**—A stainless steel bowl, 8 in. in diameter, is fitted internally with 10 Terry clips to hold 6 x 1-in. boiling-tubes. A piece of stainless steel or aluminium sheet is cut and bent into the form of a right circular cone 3 in. in diameter and riveted in that position, then being placed on its base in the centre of the bottom of the bowl. The solutions to be evaporated are placed in the boiling tubes and two or three black glass beads added to absorb the radiant energy. The lamp is placed 2 to 4 in. above the rim on the centre line of the bowl. Quiet boiling begins in a few seconds, and 10 samples, each of 20 ml. of alcohol-ether mixture, can be evaporated to dryness in about half an hour without any risk of fire or bumping (Fig. 1).

**Distillation.**—When radiant energy is used, the transfer of heat energy to a liquid can be controlled instantaneously by the turn of a switch. If the liquid to be distilled is transparent to radiant energy in the 1-2 μ band, the distilling flask must contain beads which absorb this radiation. There is no fire risk, and since glass is transparent to this wavelength the

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**Fig. 1.**—Apparatus for evaporating liquids and for drying solids.

The lamp is clamped to a rod graduated in inches and is readily moved in vertical and horizontal planes. The bowl is not fixed and can be replaced by an evaporating dish or several small crucibles.

A sample of stool sufficient for the estimation of fat by the method of Holt, Courtenay, and Fales (1919) can be dried in 10 to 30 minutes, depending on its consistency.
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Since some energy is absorbed by the reflector, after prolonged use it becomes very hot, and tends to damage the plating. This difficulty was readily overcome by immersing the reflector in a bowl of flowing cold water. The apparatus* is illustrated in Fig. 2.

Conclusions

These infra-red lamps cost about 1s. and have a life of more than 5,000 hours. Ancillary apparatus is simple and cheap. The automobile head-lamp reflector was obtained from a car breaker’s yard and was cleaned and nickel plated. They allow one to evaporate or distil inflammable solvents without hazard of fire and without mess, and can replace the muffle furnace in many metabolic studies. Even small laboratories can consider undertaking sodium and potassium balances. After a six months’ trial of infra-red lamps we are using boiling-water baths only to provide a standard temperature for the development of colours in colorimetric analysis and to hasten the rate of chemical reactions. If standard glassware could be made from infra-red absorbing glass, the radiant heat lamp could become even more useful. Discussions with some glass manufacturers are now in progress.

Summary

Infra-red lamps may be used with advantage to (1) evaporate liquids, especially inflammable liquids, (2) dry solids, (3) combust organic material. Infra-red lamps are essentially clean and lose little heat to their surroundings. Methods are described for evaporation, drying, and incineration which are more efficient and cheaper than conventional methods.

I am glad to express my thanks to Dr. George Discombe for his help and encouragement, and to Mr. F. Dewar for his help in making the apparatus.

REFERENCES


* An improved version is being manufactured by Messrs. Townson and Mercer, Croydon.