References and Notes

1. S. P. Grossman, *Am. J. Physiol.* **202**, 882 (1962).
2. N. E. Miller, K. S. Gottesman, N. Emery, *ibid.*, in press.
3. A. E. Fisher and J. N. Coury, *Science* **138**, 691 (1962).
4. B. K. Anand and J. R. Brobeck, *Yale J. Biol. Med.* **24**, 123 (1951).
5. P. Teitelbaum and A. N. Epstein, *Psychol. Rev.* **69**, 74 (1962).
6. P. Gloor, in *Handbook of Physiology*, J. Field, Ed. (American Physiological Society, Washington, D.C., 1960), section I, vol. 2, chap. 58; J. D. Green, *ibid.*, chap. 56; E. E. Krieckhaus, unpublished thesis, University of Illinois (1962).
7. P. W. Han and J. R. Brobeck, *Am. J. Physiol.* **200**, 707 (1961).

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Infrared Emission Spectra of Organic Solids from 5 to 6.6 Microns

Abstract. *The emission spectra of thin layers of a number of organic solids have been studied from 5 to 6.6 μ in the infrared to determine if there are specific emission characteristics that would allow identification of such solids as organic. This was the case only for very thin films with strong absorption bands.*

Recent successes in unmanned space flight have encouraged speculation that life on Mars might be detected by characteristic spectra in the 5- to 6.6-μ region. This region is selected because the double bonds C=O, C=N, and C=C have strong absorption at this wavelength and they occur in many organic substances. This wavelength is in the sensitivity range of lead selenide infrared detectors at temperatures of liquid nitrogen. Lead selenide has high sensitivity in this region at temperatures of liquid nitrogen. Characteristic emissions or absorptions at longer wavelengths could be detected only by detectors at much lower temperatures. At present such temperatures are unattainable on space-craft. At shorter wavelengths reflected solar radiation would obscure emission from the planet so that only reflection spectra such as those shown by Sinton (*1*) would be detectable.

To test the feasibility of observing characteristic emission spectra from 5 to 6.6 μ, experiments were made with a grating spectrometer in a vacuum chamber, a black body, and a means of heating the specimen. A spectrometer, 0.5 m Fastie-Ebert (*2*), with a grating 10 × 10 cm was used. The detector was lead selenide cooled to about 77°K by a miniature Joule-Thompson cryostat. The vacuum chamber was evacuated to eliminate water vapor and a flow of dry nitrogen was begun to the cryostat. The expansion of the nitrogen in the cryostat produced the liquid nitrogen to cool the detector. The gas exhausted from the cryostat produced an equilibrium pressure of 2 mm-Hg in the vacuum chamber. Specimens were placed in a separate chamber equipped with a valving arrangement to allow specimens to be changed without altering the pressure and temperature conditions in the main chamber. The two chambers were separated by a calcium fluoride window.

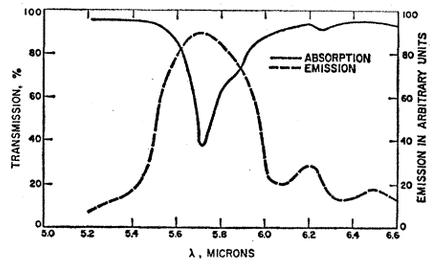
Absorption measurements were made with a black body at a temperature of 100°C as a source of infrared radiation with the specimen at room temperatures. Measurements of emission spectra were made with the sample in contact with an aluminum plate at 100°C. None of the specimens had a change in their absorption spectrum after heating.

Thin plastic films were examined first because many of them have strong absorption bands that are attributed to the double bonds. These films are mechanically stable, homogeneous, and can be acquired in a number of thicknesses. Mylar, at a thickness of 120 μ, had strong absorption bands, but was virtually without a characteristic emission and showed only an enhanced emission over that of the aluminum plate. A film of Mylar 6 μ in thickness was examined next. The absorption was pronounced although not as intense as in the thicker specimen. The emission spectrum contains a strong emission peak corresponding to the absorption feature as shown in Fig. 1.

A thin film of Teflon was placed on a polyethylene film and the same measurement was made. Polyethylene, in thin films, has virtually no absorption or emission at 5 to 6 μ and served merely as a mechanical support for the Teflon which was of the same order of thickness as the 6 μ Mylar. The strong absorption feature and a corresponding emission feature are shown in Fig. 2.

Dupont film H, a plastic similar to Mylar, was examined a 50 μ. Its pronounced absorption bands and emission spectrum are shown in Fig. 3. The emission features were far less prominent than those seen with thinner films.

As a result of the experience with plastic films, the method was next applied to organic matter. A thin film of *Bacillus subtilis*, approximately 12 μ thick, was placed on a calcium fluoride substrate and examined after it had been dried in a vacuum. Upon examination, there were neither absorption features nor emission characteristics.



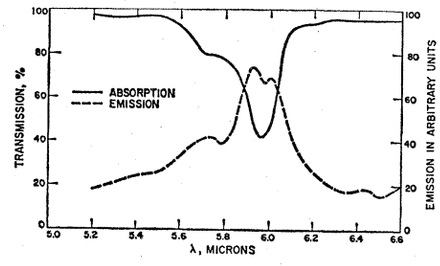
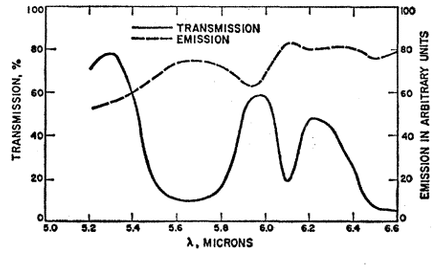


Fig. 1 (left). Emission and absorption of 6 μ Mylar. Fig. 2 (right). Emission and absorption of 6 μ Teflon.



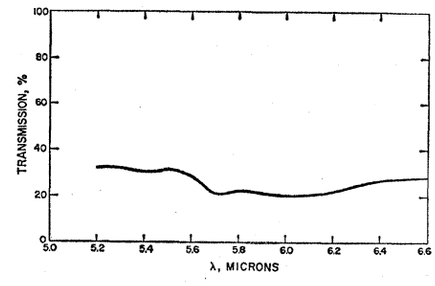


Fig. 3 (left). Emission and absorption of 50 μ film H. Fig. 4 (right). Emission of cactus epidermis.

The instrument was able to detect a 2 percent deviation from the absorption and emission characteristics that would be displayed by a black body at the same temperature and emissivity. A culture of the same bacteria on agar was examined after vacuum drying. The dried film was approximately 250 μ thick and was completely absorbing beyond 5.8 μ, but there were no recognizable emission features. A film of dried *Penicillium notatum* of approximately 12 μ had no pronounced absorption features and no emission features.

The epidermis of plants of the cactus family has been of interest because of an outer layer that inhibits loss of water; such a layer would be useful in a Martian organism. The recent work of Rea (*3*) has shown that such epidermis is very similar to paraffin in absorption and reflection. The epidermis from each of two local cacti were dried in a vacuum and examined. The dried epidermis was approximately 60 μ thick and translucent. Both showed better than 60 percent absorption at 5 to 6.6 μ with some characteristic features, though none were as pronounced as those found in the plastic films. The absorption spectrum of one of the species is shown in Fig. 4. No characteristic features were detectable in emission.

It appears, from the results described, that emission spectra of organic solids will have recognizable features for only a very limited set of conditions. For a significant emission characteristic to appear, the specimen must be thin and it must have specific absorption. The background must not radiate strongly in the 5- to 6.6-μ region; therefore, it must be a substance of lower emissivity, lower temperature, or a combination of these characteristics. The dilution of emission characteristics in the 50-μ sample of film H is striking when compared with the strong specific characteristics of the 6 μ Mylar.

The effect is readily understandable in the light of Kirchoff's law. The thin specimens emit, as a function of wavelength, in proportion to their absorptivity in the linear manner of a substance whose optical depth is less than one. As the thickness is increased, the optical depth of the specimen becomes high at all wavelengths and the radiant flux loses characteristic spectra.

These results would seem to make the prospect of detection of life on the surface of Mars by emission spectra in the 5- to 6.6-μ region remote. It is difficult to imagine organisms on a planetary surface meeting the extreme conditions necessary to produce recognizable emission features.

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References

1. W. M. Sinton, *Astrophys. J.* **126**, 231 (1957); *Science* **130**, 1234 (1959).
2. W. Fastie, *J. Opt. Soc. Am.* **42**, 641 (1952).
3. D. G. Rea, T. Belsky, M. Calvin, *Science* **141**, 923 (1963).

8 November 1963

Antibody Activity in Six Classes of Human Immunoglobulins

Abstract. *Antibody activity to thyroglobulin was identified in six classes of immunoglobulins in man, that is, in type I and type II, 6.6S γ-globulins; in type I and type II, β_{2A}-globulins; and in type I and type II, γ_1-macroglobulins. These observations indicate that antibody-activity sites are separate from the part of the H chains of immunoglobulin molecules responsible for specific properties of 6.6S γ-globulin, β_{2A}-globulin, or γ_{1M}-globulin, and, also, are separate from the part of L chains responsible for type I or type II characteristics of immunoglobulin molecules.*

Normal human serum contains six immunoglobulin groups (type I, γ-; type II, γ-; type I, β_{2A}-; Type II, β_{2A}-; type I, γ_{1M}-; and type II, γ_{1M}-globulins) (1). There are about 8 mg of type I γ-globulins and 4 mg of type II γ-globulins per milliliter in normal serum, and lesser amounts of the types I and II β_{2A}-globulins and γ_{1M}-globulins (*2*). Antibody activity has been identified in the γ, β_{2A}, and γ_{1M} subdivisions of the immunoglobulins. Our studies were undertaken to determine if antibody activity was present in the type I and type II molecules of each group, that is, in all six classes of immunoglobulins.

Serums with antibody activity against thyroglobulin were obtained from seven patients with chronic thyroiditis (*3*) and serums with antibodies against insulin were obtained from two patients with diabetes mellitus (*4*). Each serum was tested for 6.6*S* γ-, β_{2A}-, and γ_{1M}-globulin antibodies to thyroglobulins (*3*) or insulin (*4*) by radioimmunoelectrophoresis (*5*). After electrophoresis of these serums in agar, specific antiserums (*6*) were added to antiserum troughs to obtain immune precipitates of individual immunoglobulins. Labeled antigen (I^{131}-thyroglobulin or I^{131}-insulin) was then added to the troughs and diffused through the agar to combine with antibody molecules contained in the immunoglobulin precipitates. The labeled antigen and specific antibody were detected by autoradiography (Fig. 1). Thyroglobulin was taken from the α-globulin fraction obtained by zone (block) electrophoresis fractionation of thyroglobulin preparations (*3*). Labeling with I^{131} was done by the technique of McFarlane (*7*).

Seven serums containing antibodies to thyroglobulin fixed sufficient amounts of the labeled thyroglobulin so that an autoradiograph could be obtained. In five cases, both type I and type II γ-globulins had antibody activity (Fig. 1). The 6.6*S* γ-globulins were isolated from two serums by DEAE (dimethylaminoethyl) cellulose chromatography (*8*). On radioimmunoelectrophoresis antibody activity was found in the type I and type II globulins. In two additional cases, type I γ-globulins fixed a small amount of labeled thyroglobulin but none was detected in the type II γ-globulins. This difference may have been due to a relative deficiency of type II antibodies since type II γ-globulins were present in lower concentrations than those of type I and the type II may not have been detected under the conditions of the experiment. In two serums containing insulin antibodies, both type I and type II γ-globulins bound radioiodinated insulin (Fig. 1). Normal serum, however, did not bind I^{131}-insulin or I^{131}-thyroglobulin.

Our observations indicate that γ-globulins of both types I and II may have antibody activity. The relative amounts of type I and type II antibodies (as judged by the intensity of the autoradiograph lines) varied from a preponderance of type I to about equal amounts of type I and type II antibodies. Further studies were undertaken to determine whether type I and type II γ_1-macroglobulins and β_{2A}-globulins contain antibody activity.

Two serums (HM and LH) known to have antithyroglobulin activity in γ_1-macroglobulin molecules, were fractionated by a combination of block electrophoresis and filtration through Sephadex G-200 to obtain the 18*S* γ_1-macroglobulin fraction (*6*). By radioimmunoelectrophoresis and Ouchterlony diffusion with labeled antigen, the type I and type II γ_{1M}-globulins from