# Aerocolloid Formation from Semisolid Materials Exposed to Sunlight

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Submicron particle formation from airborne vapors and gases under the influence of sunlight, ultraviolet radiation, and X-rays is well known (1, 2, 3, 4, 5, 6, 7, 8, 9,). As described herein, aerocolloids have been found to be formed by the direct action of sunlight on such common materials as paving asphalt, vinyl plastic and newspapers in dry air. Direct exposure of the materials to sunlight with air passing over them generated aerocolloids, in appreciable quantities, but, unless the substances themselves were exposed to the sunlight, aerocolloid generation was below detectible levels for the instrument and system employed. Heating the substances by other means to, and beyond, the temperatures they would attain due to sunlight heating and then exposing the emitted vapors only in dry carrier air to sunlight did not produce detectible aerocolloids.

## Apparatus

The exposure chamber was a 10 x 10 x 6 cm (inside dimensions) box machined from a single block of aluminum and covered on one 10 x 10 cm face with a Vycor-quartz window. The window was fastened to the metal box by bolts and a retaining frame using a Teflon gasket. Inlet and outlet ports were provided in opposite sides of the box. Dry air (Matheson) was passed before entering the exposure chamber through a Type VSWP (0.025 μm pore size) Millipore filter. The leaving air, vapor, and aerocolloid stream passed directly to a Thermo-Systems Mass Monitor, Model 3205A. A separate aluminum plate was used to cover the exposure chamber when sunlight entry was not desired. Samples of the substances under test could be cut to fill the entire exposure chamber cavity or only part of it. First tests of substance-to-sunlight exposure and vapor-only exposure were made with half-capacity samples and the cover plate over one half and then the other half of the chamber window.

Subsequently, a stainless steel chamber of 11 cm diameter and 12 cm depth was interposed between the filter and the exposure chamber. Test substances could then be sealed in this chamber, heated, and such vapors as released subjected to sunlight in the entire exposure chamber.

Polished, platinum-plated, stainless steel discs of the same dimensions as the regular quartz collector discs of the mass monitor were substituted in this instrument in order to make use of its electrostatic precipitator when it was desired to collect aerocolloid samples for examination in a scanning electron microscope.

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The sun intensity was measured on a day-to-day basis with an inexpensive photometer of the type distributed during a national survey about five years ago by the Weather Bureau Research Station at the Robert A. Taft Sanitary Engineering Center, the photometer having been found to be quite stable. It was calibrated against a system consisting of a Hewlett-Packard Radiant Flux Meter, Model 8330A, and a Radiant Flux Detector, Model 8334A, the calibration of which was traceable to the standard of total irradiance of the National Bureau of Standards.

## Procedure

The apparatus was assembled on the roof of the four-story Chemical Engineering Building near downtown Atlanta. Tests were conducted in late Summer and early Fall of 1971. After cleaning, installing the test substance, and assembling the apparatus, dry air at a flow rate of 0.5 l/min was established through the system. The exposure chamber was oriented in relation to the sun position for maximum radiation, sunlight being blocked initially from the test substance by the cover plate. The mass monitor was subsequently checked for a period of at least 15 minutes to see that its indication was stable; no significant aerocolloid mass was ever indicated during this period or during standardizing tests without substances in the chamber.

The exposure chamber cover was removed, or half removed in some tests, to initiate exposure to sunlight. The sunlight intensity was measured immediately before a test was begun and shortly after it was terminated. Clear days were selected for the tests. In only one instance was there a significant variation in intensity during sample exposure; then a small cloud briefly obscured the sun.

## Results and Discussion

Figures 1 and 2 show the mass monitor indication of accumulated aerocolloid mass as a function of time from shortly before substance exposure, through the exposure period, and for the time thereafter for accumulation to cease. It will be noticed that in one case, that of the asphalt designated AC8, there was a reduction in collected aerocolloid mass subsequent to irradiation, indicating, perhaps, partial evaporation.

Figure 3 presents scanning micrographs of typical particles from the AC8 asphalt on platinum surfaces. These particles were not shadowed prior to examination; they are thus able to survive for considerable periods in the vacuum of the microscope. They appear to be entirely under 0.5 µm in diameter. The estimated mean diameter is 0.2 µm.

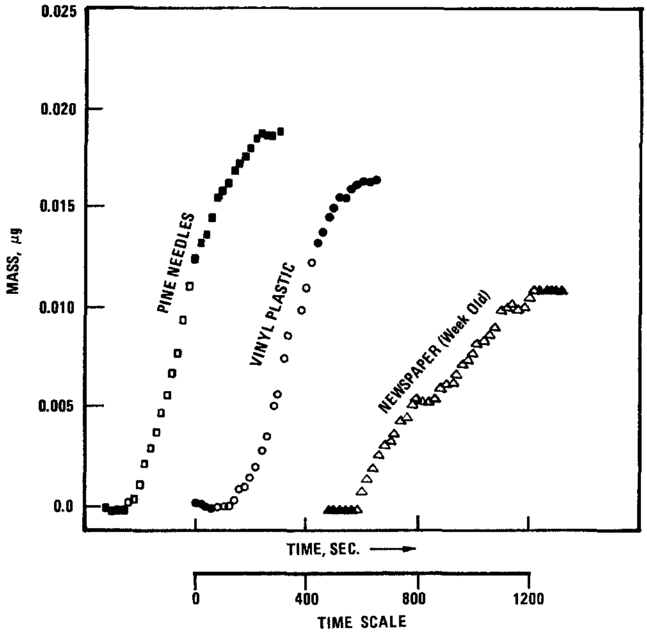

Fig. 1. Accumulation of Aerocolloid Mass from Various Materials exposed to Sunlight in Dry Air. Light intensities in Table I. Open data points indicate exposure; solid points, darkness.

Table I presents rate of particle formation data calculated from the slopes of the curves of Figures 1 and 2 during the exposure period and the dimensions of the exposed surfaces, except for the pine needles. Here the calculation is based on the mass of sample since the surface area would have been difficult to estimate.

### TABLE I

### Aerocolloid Formation Rate

| Substance | Sunlight Intensity | Rate | |
|---|---|---|---|
| | ($w/cm^2$) | ($\mu g/min/cm^2$) | ($\mu g/min/g$) |
| Asphalt, BC70 | 0.059 | $10.1 \times 10^{-4}$ | -- |
| Asphalt, AC8 | 0.061 | $13.0 \times 10^{-4}$ | -- |
| Vinyl Plastic | 0.052 | $3.8 \times 10^{-4}$ | -- |
| Newspaper (week old) | 0.066 | $0.8 \times 10^{-4}$ | -- |
| Pine Needles | 0.103 | -- | $5.0 \times 10^{-3}$ |

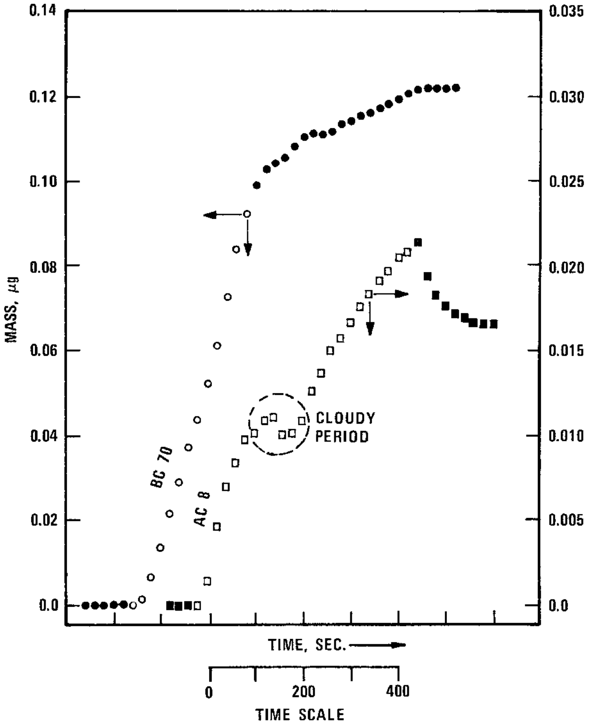

Fig. 2. Accumulation of Aerocolloid Mass from Two Types of Asphalt Exposed to Sunlight in Dry Air. Light intensities in Table I. Open data points indicate exposure; solid points, darkness.

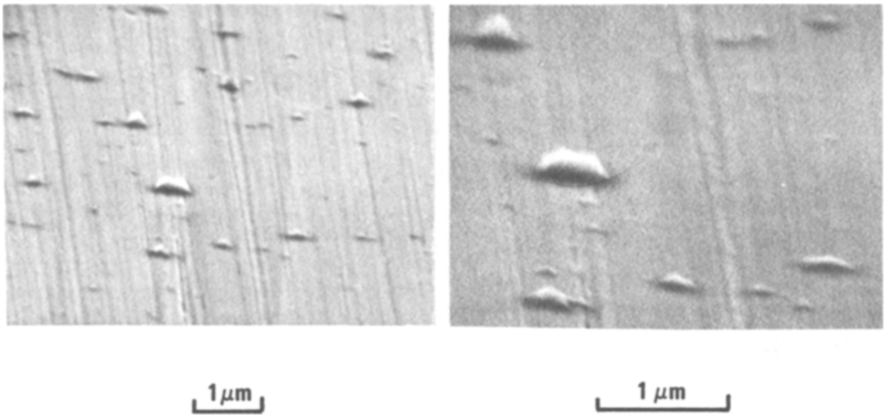

Fig. 3. Aerocolloids from Type AC8 Asphalt Exposed to Sunlight in Dry Air.

Based on accumulated stability evidence for the mass monitor, rates of aerocolloid formation of less than $3 \times 10^{-6}$ $\mu g/min/cm^2$ could not have been distinguished above the background electrical noise. Hence it is entirely possible that lesser, but undetected, rates of formation do occur in the gas phase. The fact remains that considerably greater rates of formation prevailed when the substances were irradiated directly.

Taking the estimated mean aerocolloid diameter of 0.2 μm, assuming a particle density of 1 $gm/cm^3$ and the measured rate of emission of $10.1 \times 10^{-4}$ $\mu g/min/cm^2$ for one 100 $cm^2$ surface of asphalt, it is calculated that $2.4 \times 10^5$ particles/min/$cm^2$ were being created. Similar calculations for the vinyl plastic and newspaper are $9.1 \times 10^{-4}$ and $1.9 \times 10^4$ particles/min/$cm^2$, respectively.

## Conclusion

Substances heretofore little considered, to these investigators' knowledge, may contribute significantly to urban atmospheric haze because they are exposed in great quantities to sunlight.

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