Plastics on the Sargasso Sea Surface
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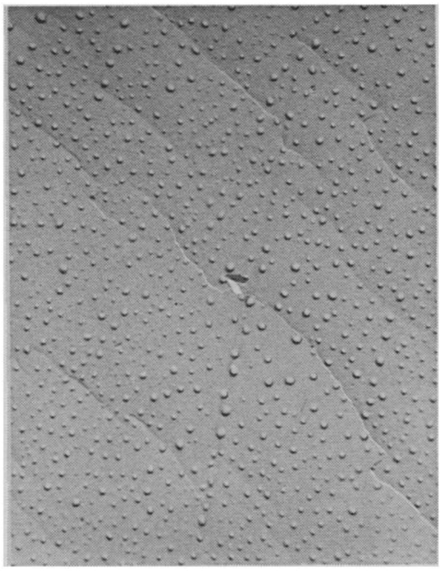

Fig. 2. Electron micrograph of wax particles generated from a pine needle at 20 kv (the torn area in the center is 0.7 μm long).

from the cuticle only while a leaf is growing (*5*), and, because of the lack of seasonal variation in wax composition (*6*), the wax coating apparently is not further affected by the plant metabolism (*7*). Although the wax layer on the tips of some pine needles is relatively smooth, other needles of comparable age from the same or from another pine tree may exhibit shapes similar to those shown in Fig. 1 (*Pinus echinata*). Wax fingers are also found on other species of trees. The tips exhibiting the elongated wax fingers tend to be in exposed areas such as on the tops of trees, on the outside of a lone tree, or on the margin of a stand. Melting of the wax cannot be invoked as an explanation for the observed configuration for several reasons, chief among which is that the tips point upward.

It is suggested that the wax fingers represent the preserved record of a conduction path which became molten during the atmospheric phenomenon usually referred to as brush discharge. To test that hypothesis, pine needle specimens were mounted on one of a pair of electrodes in a closed system and subjected to various electrical gradients in the laboratory. In each case carbon-coated disks were attached to the opposite electrodes, and the collected particulates were replicated and examined with an electron microscope. Particles collected when the pine needle was raised to a potential of 20 kv with respect to a flat plate 20 cm away are shown in the electron micrograph (Fig. 2). At lower potentials the particles were similar in size but less concentrated, whereas at 30 kv the wax fingers began to shatter and irregular strips and chunks were collected. The small wax particles released under low to moderately high potential gradients have diameters in the size range < 0.6 μm; particles in this size range may be a major factor in the production of blue haze.

Chalmers (*8*) has measured a significant conduction current passing through a small tree. The local, flat-field potential gradient easily can reach several thousand volts per meter as electrified clouds pass overhead; in an electrical storm gradients much higher than this may be recorded. These observations suggest that discrete wax particles in the appropriate size range to produce blue haze are generated by natural forces in the environment. Other types of vegetation, including grasses, could, in principle, emit wax particles under similar conditions. In the brush discharge phenomenon, high potential gradients occur at the sharp edges and tips of leaves, producing a blue glow at night. Undoubtedly, such factors as the dielectric strength of the wax, its melting point, the ambient temperature, the radius of curvature of the underlying conductive surface, and the exposure of the plant all have some bearing on the rate of production of wax aerosols. Other extrinsic factors, such as gaseous or particulate air pollutants, may affect the properties of the wax so as to reduce or enhance the rate of wax attrition, possibly leading to the denudation of the needle tip and the eventual loss of the needle because of excessive drying.

Went (*2*) has suggested that the blue haze aerosols, returned to the ground by various natural processes, may be a source of the petroleum formed in earlier geological periods. The presence of significant quantities of waxes in crude oil and the observation of a mechanism for the generation of wax aerosols in the environment suggest that the wax particles, which may serve as condensation nuclei for terpenes and other organic gases, may be a complementary factor in the phenomena described by Went. Another implication is that radioactive fallout collected on the sharp edges and tips of vegetation may be reemitted to the atmosphere during the next thunderstorm after its initial deposition. In this same connection, particulate silver iodide from cloud-seeding operations may be retained locally for a period of time and be reentrained into an unseeded cloud, producing the "memory effect" that has been observed by some atmospheric scientists (*9*).

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Plastics on the Sargasso Sea Surface

Abstract. *Plastic particles, in concentrations averaging 3500 pieces and 290 grams per square kilometer, are widespread in the western Sargasso Sea. Pieces are brittle, apparently due to the weathering of the plasticizers, and many are in a pellet shape about 0.25 to 0.5 centimeters in diameter. The particles are surfaces for the attachment of diatoms and hydroids. Increasing production of plastics, combined with present waste-disposal practices, will undoubtedly lead to increases in the concentration of these particles. Plastics could be a source of some of the polychlorinated biphenyls recently observed in oceanic organisms.*

While sampling the pelagic *Sargassum* community in the western Sargasso Sea, we encountered plastic particles in our neuston (surface) nets. The occurrence of these particles on the sea surface has not yet been noted in the literature [we also collected petroleum lumps, which have received attention (*1, 2*)].

The plastics were collected with a neuston net (*3*), 1 m in diameter with 0.33-mm meshes, towed at 2 knots (1 knot = 1.85 km/hour) on cruise 62 of the *Atlantis II* (27 September to 18 October 1971). The particles of plastic were manually sorted from the contents of the neuston tows; they were counted and their weights were determined on shore with a Mettler H 15 balance. Plastics were present in all 11 neuston tows (Table 1). Their occurrence was widespread, since the distance from the southernmost to the northernmost tow was 1300 km.

There were, on the average, about 3500 plastic particles per square kilometer (the range was from 50 to 12,000). This density gives a mean of one particle per 280 m^2 and a maximum of one particle per 80 m^2. The weight per square kilometer was from 1 to 1800 g and averaged about 290 g. The lowest concentrations were observed at stations 10 and 11, as we began to enter the Gulf Stream.

Most of the pieces were hard, white cylindrical pellets, about 0.25 to 0.5 cm in diameter, with rounded ends (Fig. 1). Chemical weathering and wave action may have produced the pellet shape. Many pieces were brittle, which suggests that the plasticizers had been lost by weathering. Some had sharp edges, which indicates either recent introduction into the sea or the recent breaking up of larger pieces. A few particles (6 percent by number) were colored green, blue, or red, and there were also a small number of clear sheet plastics. Several larger pieces could be identified as a syringe needle shield, a cigar holder, jewelry, and a button snap. From the variety of identifiable objects, it was evident that many types of plastics were present. Solvent assays and burning properties of some of the white pellets indicated that they were not polystyrenes, acrylics, or polyvinyl chlorides.

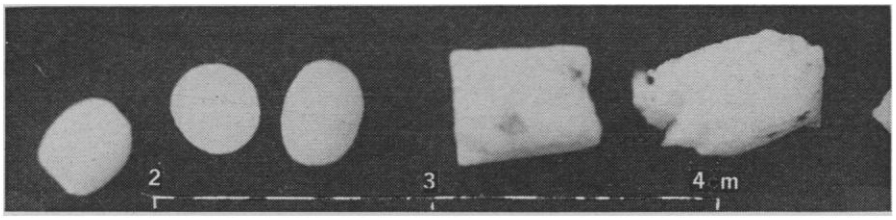

Fig. 1. Typical plastic particles from tow 2. White pellets are on the left.

Table 1. Neuston tow data.

Tow number	Date (October 1971)	Towing time (hours)	Location at start	Number collected	Weight collected (g)	Concentration	
						Number/km²	g/km²
1	12	2.25	30° 10.5′N 60° 02.5′W	5	0.31	601	37.7
2	12	2.66	30° 19.4′N 60° 00.9′W	48	2.48	4,877	251.9
3	12	4.08	30° 55.6′N 59° 57.1′W	22	1.06	1,457	70.2
4	13	1.00	31° 51.7′N 60° 37.8′W	4	0.22	1,081	60.0
5	13	0.50	32° 25.2′N 61° 14.6′W	8	0.73	4,324	395.1
6	14	6.50	33° 32.5′N 62° 30.9′W	62	2.48	2,579	103.3
7	14	0.85	34° 21.8′N 62° 53.0′W	38	5.57	12,080	1,770.7
8	15	1.00	35° 15.4′N 63° 46.3′W	17	0.96	4,595	258.9
9	15	0.85	35° 37.4′N 64° 20.8′W	22	0.64	6,994	201.9
10	16	1.00	37° 02.0′N 65° 41.0′W	1	0.22	270	4.9
11	16	5.75	37° 00.5′N 65° 34.8′W	1	0.08	47	0.6
					Mean	3,537	286.8

Most plastics had populations of hydroids and diatoms attached to their surfaces. We noted the hydroids *Clytia cylindrica* and *Gonothyraea hyalina* and the diatoms *Mastogloia angulata, M. pusilla, M. hulburti, Cyclotella meneghiniana,* and *Pleurosigma* sp. With the exception of the last, these species have previously been observed on pelagic *Sargassum* (*4*). Hydroids and diatoms have not been reported on petroleum lumps, whereas goose barnacles *(Lepas)* and isopods *(Idotea)* have (*1*).

The source of the particles may have been the dumping of waste from cities or by cargo and passenger ships. However, no metropolitan dumping occurs in the areas sampled, although some of the southernmost sample areas are within major shipping lanes from Europe to Central America and the Panama Canal. The station closest to land, station 6, was 240 km northeast of Bermuda. Stations 10 and 11, the closest to the continent, were about 900 km southeast of New York City.

Plastics have been produced in large quantities only since the end of World War II. The increasing production of plastics, combined with present waste-disposal practices, will probably lead to greater concentrations on the sea surface. At present, the only known biological effect of these particles is that they act as a surface for the growth of hydroids, diatoms, and probably bacteria.

Many plastics contain considerable concentrations of polychlorinated biphenyls (PCB's) as plasticizers. If the plasticizers have been lost to seawater, as suggested above, the incorporation of PCB's by marine organisms is possible. Polychlorinated biphenyls have recently been observed in pelagic *Sargassum* and oceanic animals (*5*).

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