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Decomposition of Ozone on Natural Sand

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Synopsis. Ozone decomposition on natural sand has been studied with a flow system. Ozone decomposed significantly on natural sand and in particular on iron sand. Silica, alumina, and iron oxides, the major components of the sand, were also capable of decomposing ozone.

Ozone is one of the major photochemical pollutants and its behavior in the environment has been reported. Ozone is reactive, which suggests that ozone may be decomposed on terrestrial substances on the ground or in airborne dusts. There have been several reports describing the heterogeneous decomposition of ozone on solids. Harteck and Dondes reported the decomposition of ozone on glass wool,1) and Mahieux studied the decomposition of ozone on glass, aluminium, copper, silica gel, and active charcoal.2) These investigations were qualitative and conducted at relatively high concentration (several %). No report has been published concerning the decomposition of ozone at low levels of concentration *e.g.*, several ppm.

The present paper describes the decomposition of ozone on natural sea sand in order to clarify the decomposition of ozone on terrestrial substances. Natural sea sand was used since it is easy to handle and has a relatively uniform composition.

Experimental

Materials. *Natural Sea Sand*: The sample was supplied from the seashore of Futsu Cape, Tokyo Bay, Japan. The sample was sieved between 80 and 120 mesh, and dried at 150 °C for three hours in an electric furnace.

Iron Sand and Remainder-sand: Natural sea sand was subdivided into iron sand and remainder-sand by means of a magnet and dried identically.

Silica, Fe_2O_3, Fe_3O_4, and Al_2O_3: Commercial reagents were employed; silica(α-quartz), α-Fe_2O_3(hematite), Fe_3O_4 (magnetite), and α-Al_2O_3(corundum). They were dried identically.

Instruments. Reactions were conducted in a flow system. An ozone generator (Tokyo Kogyo Co.) supplied a given concentration of ozone (0—5 ppm). The air containing ozone was blown into the reaction cell, filled with the appropriate sample powder. Sample powders were supported on glass frit and Teflon filters. The concentration of ozone was measured by a UV absorption type ozone monitor (Dasibi Co.) at the inlet and the outlet of the reactor. The flow rate of the ozonized air was regulated at 2 l/min by the suction pump of the ozone monitor.

Results and Discussion

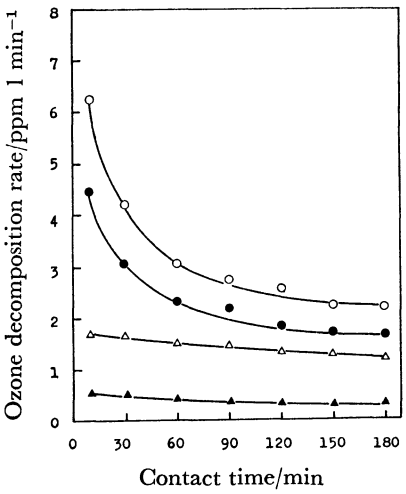

Fig. 1. Decomposition rate of ozone on natural sand (5 ml) *versus* contact time.
Concentration of ozone at inlet; -○-: 5 ppm, -●-: 3.5 ppm, -△-: 1.0 ppm, -▲-: 0.25 ppm.

Ozone Decomposition on Natural Sea Sand. No ozone was decomposed in blank tests in the absence of sample materials in the reactor. Ozone decomposition was seen to take place on the natural sand sample charged in the reactor. Figure 1 shows the variation in the rate of decomposition of ozone with contact time on the natural sand (5 ml). The decomposition rate was determined as follows:

$$\text{Decomposition rate} = ([O_3]_i - [O_3]_o) \times f$$

$[O_3]_i$: Inlet ozone concentration (ppm)
$[O_3]_o$: Outlet ozone concentration (ppm)
f: Flow rate of air (l/min)

The rate of decomposition decreased gradually with increase in concentration, whereas the rate remained almost constant at low ozone concentration.

The decomposition rate of ozone at constant concentration (3.5 ppm) increased in proportion to the volume

TABLE 1. ANALYSIS OF SAND

Component	Sieved sand a) (wt %)	Original sand b) (wt %)	Analytical method
SiO_2	57.18	68.21	alkaline fusion, $HF+H_2SO_4$
Fe_2O_3 c)	21.73	13.43	EDTA chelatometry
Al_2O_3	10.11	9.09	
CaO	3.30	4.59	
MgO	3.76	3.44	
$H_2O(-)$	0.66	0.59	
$H_2O(+)$	1.25	2.27	
Mn	0.33		atomic absorption photometry
Cr	0.01		
Zn	0.01		

a) Natural sand sieved between 80 and 120 mesh, and provided for exposure to ozone. b) The original natural sand was used without sieving. c) Fe content expressed as Fe_2O_3.

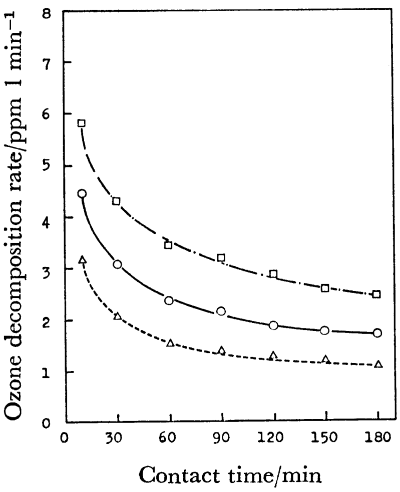

Fig. 2. Decomposition rate of ozone on various components of the sand *versus* contact time.
-○-: Natural sand (5 ml), —□—: iron sand (5 ml) ---△---: remainder-sand (5 ml).

of the sand.

Individual Activity of the Components of Natural Sand in Ozone Decomposition. The decomposition was studied on several components of sand; iron sand, remainder-sand and some reagents. The reagents are those which were found by chemical analysis to be the major components of the sand; *i.e.* silica, iron oxides, and alumina. The major component of iron sand is known to be Fe_3O_4, so that α-Fe_2O_3 and magnetite were investigated.

Natural sand was analyzed by chelatometry and atomic absorption spectrometry, the results of which are given in Table 1. The sand used in the experiments contained more iron oxides than the original non-sieved sand probably because the iron sand grain size is mainly distributed in the 80—120 mesh range. In measurements of ozone decomposition the amounts of samples used were: remainder-sand (5 ml), iron sand (5 ml), silica (5 ml), Fe_2O_3 (5 ml), alumina (1 g), and Fe_3O_4 (1 g). Figure 2 shows the rates of ozone decomposition on iron sand, remainder-sand and natural sand.

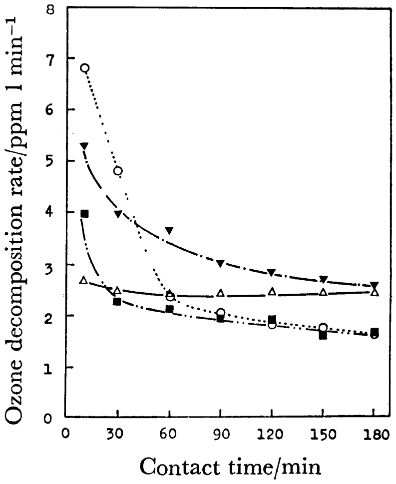

Fig. 3. Decomposition rate of ozone on several materials *versus* contact time.
···○···: Fe_2O_3 (5 ml), —▼—: Fe_3O_4 (1 g), —■—: Al_2O_3 (1 g) -△-: SiO_2 (5 ml)

The rate on iron sand was higher than that on natural sand suggesting that iron sand more effectively decomposes ozone than remainder-sand.

The decomposition rates on alumina, Fe_2O_3 and Fe_3O_4 were lower, whereas that on silica remained almost constant as shown in Fig. 3. The decomposition on Fe_3O_4, a major component of iron sand, behaved very similarly to that on iron sand as shown in Figs. 2 and 3.

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References

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2) F. Mahieux, *Genie Chim.*, **87**, 15 (1962).