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Adsorption of air pollutants on the grain surface of Japanese cedar pollen

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Abstract

The contaminants adsorbed on the surface of pollen may affect the development of hay fever, because the patients of the fever are larger in areas with much air pollution than in nonpolluted areas and the fine particles and gases are susceptible to deposit on the nasal cavities and eyes by their transfer on the pollen. Since Japanese cedar pollinosis is the most common hay fever in Japan, we analyzed the air pollutants adsorbed on the surface of dispersed Japanese cedar pollen in the urban and mountainous districts. Fine anthropogenic particles were significantly adsorbed and many elements were concentrated on the surface of the pollen in the urban site of Yokohama, while they were not concentrated on the surface of the pollen collected at a mountainous site. The acid gases are also adsorbed and acidify the surface, and their amounts increase with their concentrations in the ambient air. The high adsorption of nitric acid on the pollen determined by an exposure experiment of nitric acid gas suggests that nitric acid is dissolved in the inner part of the pollen. The adsorption amounts of the gases on the pollen were especially greater than those on other natural particles, humic acid and yellow sand.

Keywords: Hay fever; Japanese cedar pollen; Air pollution; Aerosol; Acid gases

1. Introduction

Allergic disease have been on the increase during the past decades (Wahn, 2000) and hay fever has become a serious disease in the world's large cities (Fleming and Grombie, 1987; Settipane, 1986). The number of patients has significantly increased especially for the Japanese cedar pollen allergy in Japan which is now over 10% of the Japanese population (Okuda and Shida, 1998; Teranishi and Fujisaki, 2003). Allergy develops as a result of multiple interactions between the human immune system and the environment. The adjuvant factors of the environment play an important role in the increasing problem of pollen allergy. Air pollution can cause an increase in airway reactivity through mechanisms dependent on or independent of specific IgE antibodies (Obtulowicz, 1993). Ishizaki et al. (1987) reported that the patients of Japanese cedar pollinosis is larger in areas with much air

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pollution than in nonpolluted areas, while the pollen counts in both areas were almost the same. They also pointed out that the increasing factors in Japan are regarded to be (1) the increase in the dispersed pollen amounts in ambient air, (2) the suppression of the immune system by urbanization, and (3) air pollution. As for the relationship between the pollinosis and air pollutants, the simultaneous exposure of the ultrafine particles of a exhausted diesel gas and Japanese cedar pollen grains was proved using the serum and a mouse that had an increased incidence of hay fever (Maejima et al., 2001). Steerenberg et al. also showed that the IgE antibody response was higher in rats immunized with not only pollen grains but also diesel exhaust particles (DEP) than rats immunized with only pollen (Steerenberg et al., 1999). The ultrafine particles of nano to submicro order DEP, however, are too small to deposit by themselves on the nasal cavity or the eyes where the pollen grains deposit. The contaminants adsorbed on the pollen grain surface may affect the development of hay fever, because the grain size of pollen is sufficient to deposit there, and the grains act as vectors for the ultrafine particles of DEP. The Japanese cedar pollen grain has a very large specific surface because of the concavoconvex surface with fine particles of ubish bodies (Uehara and Sahashi, 2000), and floats for a long time in the ambient air due to its small size and low density. Much air pollutants deposit on the surface of the grains while floating before the deposition of the grains on the mucus of the human body (Cerceau-Larrival et al., 1994).

In this study, we compared the surface composition of the Japanese cedar pollen dispersed in an urban district, Yokohama, with that obtained in a mountainous district, Mt. Oyama, and the pollen collected directly from the male flower as the control pollen. We also examine the adsorption behaviors of the pollen surface for acid and ammonia gases in Yokohama using the control pollen. The ultrafine anthropogenic particles were found to be highly adsorbed on the surface of the dispersed pollen in the urban site. The acid gases were also adsorbed and acidified the surface, and their amounts increased with their concentrations in the ambient air. The pollution of the surface of the dispersed pollen in the urban region may trigger the pollinosis, because the concomitance of heavy metals promotes the allergic reaction (Lambert et al., 2000) and the acid gases cause inflammation of the airway (Obtulowicz, 1993).

2. Experimental section

Durham type pollen collectors were set up on the rooftop of a six-story building of Kanagawa University in the center part of Yokohama city (35°28′N, 139°38′E) and the open space (680 m asl) of Mt. Oyama (35°28′N, 139°46′E, 1252 m asl). In Mt. Oyama, most of its area is covered with forest and Japanese cedar is one of the dominant trees. The control pollen were collected directly from the male flower of Japanese cedar, and stored in an airtight container in a refrigerator until the experiments. Dispersed pollen was passively collected on the electroconductive carbon tape pasted on the aluminum sample stage of an SEM-EDX in February and March of 2002, 2003, and 2004. The pollens were analyzed with a scanning electron microscope (S-4000 HORIBA)—energy dispersion X-ray analyzer (EMAX-2770 HORIBA). The accelerating voltage of an EDX for the analysis was 25.0 kV and the measurement time was 100 s. The elements with an atomic number <10 cannot be measured by the EDX, and, therefore, their adsorption on the pollen was not discussed.

To examine the acid and ammonia gas adsorption characteristics on the surface of Japanese cedar pollen, the pollen was exposed to the atmosphere using a multistage filter holder (each filter area, 17 cm^2) and a suction pump (9 l min^{-1}). The configuration of the filter holder was as follows: the quartz fiber filter in the first stage was used to remove aerosols; the Japanese cedar pollen (about 0.12 g) was spread on the quartz fiber filter in the second stage; the impregnated cellulose filters for the collection of the acid and ammonia gases were placed in the 3–6th stages as reported by Igawa et al. (2002). Another filter holder without the pollen layer was also prepared to collect the acid and ammonia gases for analysis. The Japanese cedar pollen on the quartz fiber filter was immersed in 20 ml pure water after exposing to the ambient air, and irradiated by ultrasonics for 30 min to extract the water soluble components sorbed on the pollen. The solution was filtered with a membrane filter (0.45 μm), and analyzed using an ion chromatograph (DIONEX DX-120 with DIONEX Ion Pac AS12A column).

To evaluate the properties of the nitric acid adsorption on the pollen, nitric acid gas was generated from a generator, which is composed of three serially joined impingers. The first impinger contained a 1.5 M nitric acid aqueous solution, the