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Solanesol: A Tracer for Environmental Tobacco Smoke Particles

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■ Concern about the health effects of passive smoking and exposure of a large population to environmental tobacco smoke have generated the need for a quantitative tracer of environmental tobacco smoke. Solanesol, a trisesquiterpenoid alcohol, has been shown to be present in environmental tobacco smoke. Results from the determination of particulate-phase solanesol in environmental tobacco smoke in both chamber and indoor environments show that solanesol is a suitable tracer for the particulate phase of environmental tobacco smoke.

Introduction

Environmental tobacco smoke (ETS) is an important component of indoor air pollution. Data in the literature indicate that exposure to environmental tobacco smoke leads to an increased incidence of respiratory disease and the impairment of lung development in children, and to the development of lung cancer (*1*, *2*). These health concerns and the exposure of a large population to environmental tobacco smoke have generated the need for a quantitative tracer of ETS.

According to a review by the National Academy of Sciences (*1*), a suitable tracer for quantifying environmental tobacco smoke concentrations should be (1) unique or nearly unique to environmental tobacco smoke, (2) easily detected in air, even at low smoking rates, (3) similar in emission rates for a variety of tobaccos, and (4) in constant proportion to compounds in ETS that have effects on human health. Tracers of environmental tobacco smoke used in the past include respirable (or total) suspended particulate matter (RSP), CO, nitrogen oxides, nicotine, *N*-nitrosamines, aromatic hydrocarbons, and frequency of smoking. Recent reviews of environmental tobacco smoke by the National Academy of Sciences (*1*) and the U.S. Surgeon General (*2*) reach the same conclusion, i.e., the only tracers previously used that may be related to actual exposure to environmental tobacco smoke are concentrations of nicotine and RSP. As pointed out in these reviews, both of these tracers have potential problems.

The use of nicotine as a tracer of environmental tobacco smoke is complicated by the fact that nicotine is found primarily in the gas phase in the environment (*3*–*6*). Furthermore, nicotine is strongly basic and is removed from indoor environments at a faster rate than particulate-phase nicotine or the particulate portion of environmental tobacco smoke (*1*, *6*–*10*). Thus, the concentration of gas-phase nicotine may underestimate exposure to the particulate phase of ETS. In addition, the gas-/particulate-phase distribution of nicotine may be altered during sampling. Badre et al. (*11*) found an 80% loss of added nicotine from filters after sampling for 50 min at 4 standard L/min (sLpm). Similar effects have been noted when sampling for nicotine in environmental tobacco smoke particles on filters (*12*, *13*). The experimentally determined concentration and phase distribution of nicotine may thus be dependent on the sampling system used.

Because of the ease with which it may be measured, total RSP has been commonly used as a tracer for environmental tobacco smoke in past studies (*1*, *2*). However, several studies (*6*, *14*, *15*) have shown that even though RSP is elevated in environments where smoking is present, about half of the RSP in these environments does not come from environmental tobacco smoke. RSP thus overestimates exposure to environmental tobacco smoke.

Solanesol, a trisesquiterpenoid alcohol in tobacco leaf,

$$CH_3C(CH_3)=CH(CH_2CH_2C(CH_3)=CH)_4CH_2OH$$

has been shown to be present in tobacco smoke condensate (*16*, *17*) and environmental tobacco smoke (*18*, *19*). Studies previously reported by Ogden et al. (*18*, *19*) suggest that the concentration of solanesol in ETS particles is conserved in the indoor environment. Solanesol is nonvolatile because of the large molecular weight (631) and, hence, is present only in the particulate phase of environmental tobacco smoke (*18*). In this paper, the potential use of solanesol as a tracer for environmental tobacco smoke is evaluated. The concentrations of solanesol in controlled chamber studies and in indoor environmental tobacco smoke were determined and compared to several other components of ETS.

Methods

Sample Collection. Particulate samples for the determination of solanesol in simulated environmental tobacco smoke were obtained from sidestream smoke generated in a collapsable 30-m^3 Teflon chamber (*5*, *6*). In these experiments, either one-half or four cigarettes (1R1 and 1R4F research cigarettes, University of Kentucky) were smoked in the Teflon chamber using a standard cycle (*5*). The mainstream portion of the smoke was vented to the outside of the chamber. Samples of the generated particles were passed through a 10-mm Teflon line and collected on quartz filters (2500 QAST, Palliflex Products Corp.) at 1-h intervals over a ~4-h period after combustion of the cigarette (*5*). Before use, the filter was washed with 0.1 M HCl at 60 °C for 12 h, thoroughly rinsed with water, and heated at 300 °C for 12 h. The sample flow rate was set at 30 sLpm (standard liters per minute, 25 °C and 1 atm) by use of a Tylan mass flow controller.

In addition to the collection of particles for the determination of solanesol, the CO and total particulate concentrations in the chamber during each of the experiments were determined with a CO detector and a piezobalance, as previously described (*4*, *5*). The concentrations of particulate-phase nicotine and of gas-phase nicotine and 3-ethenylpyridine were determined by sampling with a benzenesulfonic acid coated annular denuder followed by a quartz or Teflon filter to collect particles and a benzenesulfonic acid coated quartz filter to trap any alkaloids lost from the particles during sampling, as previously described (*5*, *13*).

Particulate samples for the determination of solanesol were also obtained during a study to compare sampling techniques for nicotine (*13*). Environmental tobacco smoke in these studies was generated in the chamber facility at the Pierce Laboratory by volunteer smokers. The concentration of tobacco smoke constituents was controlled by the rate of chamber ventilation. Samples for determination of solanesol were collected on 47-mm Teflon

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