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Airborne contact dermatitis – mechanisms of contact allergen release from plants

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Airborne allergens may produce lesions in the exposed portions of the skin, such as face, neck, hands, forearms, and/or lower legs leading to an airborne contact dermatitis (ABCD). Plants are a rich source of airborne allergens and irritants and consequently ABCD caused by plants are relatively common. Airborne allergens can be spread via (i) indirect contact (e.g., hand-borne), (ii) direct release (emission) from plants, (iii) oxidation of non-allergenic volatiles to allergens in the air or on the skin, and (iv) by the release of small plant particles (e.g., pollen or dust particles). The most obvious mechanisms of release of allergens from plants are, however, through airborne pollen or dust particles containing small amounts of contact allergens or by direct release of volatile allergens. Hence, focus will be on these mechanisms of contact allergen release illustrated by the direct release of the quinone primin from Primula obconica and the release of the sesquiterpene lactone parthenolide (PHL) through small plant particles from feverfew (Tanacetum parthenium).

The most important criteria for direct emission of allergens in the air is that they should be volatile i.e. have a high vapour pressure, which usually are valid for small molecules with a molecular weight below 300 g mol⁻¹ with only a few hydrophilic groups in their structures. Secondly, the volatile allergens should be situated near the surface of the plants in trichomes or in outer cells/oil glands making a direct release possible. The volatile allergens are collected from the living plants by dynamic headspace (DHS) technique followed by analysis of the headspace extracts by gas chromatography (GC) combined with a mass spectrometry (MS) detector making it possible to identify and quantify the released volatiles.

The sensitizing properties of Primula, in particular P. obconica, are primarily due to the accessibility of the allergen primin (2-methoxy-6-n-pentyl-1,4-benzoquinone) on the surface of the plant (Christensen & Larsen, 2000). Primin and related compounds such as the hydroquinones miconidin and miconidin methyl ether are formed in minute glandular hairs (trichomes), and are accumulated between the cuticula and the cell membrane of the outermost cells. When the cuticula burst, the allergen accumulates as irregular resinous drops on the top and sides of the hair. The contact allergens of P. obconica fulfil the requirements of volatility and it has been shown by the use of DHS techniques that these contact allergens are released from intact plants. For primin, the release corresponded to approximately 580 ng plant⁻¹ h⁻¹ at room temperature, which is clearly enough to elicit an allergic reaction in highly sensitized patients (Christensen & Larsen, 2000). Primula dermatitis has variable clinical manifestations, which is often misdiagnosed since patients normally do not present a typical picture of plant dermatitis with blotches and linear strikes on the skin (Rook & Wilson, 1965; Hjorth, 1970). The main pattern of primula dermatitis is facial dermatitis, alone or in combination with limb or hand dermatitis (Aplin & Lowell, 2007; De Corrés et al., 1987; Hjorth, 1970; Mitchell & Rook, 1979; Rook & Wilson, 1965). Most cases of primula dermatitis are due to direct contact with the plants whereas only a few cases of airborne contact dermatitis have been described (Aplin & Lovell, 2007; Dooms-Goossens & Deleu, 1991). Therefore, airborne primin and related compounds should be taken into consideration...
when investigating the possibilities of primula dermatitis, in particular ABCD. Examples of direct emission of strong allergens from plants are, however, few as many of these allergens are not volatile \textit{per se}. However, volatiles with low allergenic potential such as eugenol, isoeugenol, limonene, and α-pinene are emitted from many plant species and are well known constituents in natural and synthetic fragrances (De Groot & Frosch, 1997).

For many years it has been debated whether strong contact allergens, in particular sesquiterpene lactones, are able to be spread via pollen or dust particles explaining many cases of ABCD, in particular, those related to the classical form of Compositae dermatitis with the typical airborne pattern eczema (Paulsen et al., 2007). Feverfew, which is related to \textit{Parthenium hysterophorus} a frequent sensitizer of Compositae-allergic patients in India, is allegedly an important cause of airborne Compositae dermatitis in Europe (Hausen & Vieluf, 1997; Mensing et al., 1985). The most important allergen in feverfew is the non-volatile sesquiterpene lactone PHL and the question is whether this sesquiterpene lactone is released from the plant in amounts high enough to explain its cause to airborne Compositae dermatitis? In order to investigate this hypothesis, flowering feverfew plants were placed in a greenhouse in proximity to a high volume air sampler (HIVAS) capable of capturing plant particles down to 4 μm in size. Analysis of the HIVAS extracts by GC–MS showed that PHL is released from feverfew plants in a concentration of approximately 100 ng h\textsuperscript{−1}. This means that a border of feverfew plants may release milligrams of the allergen. The testing of 12 feverfew-allergic patients revealed that 8 had positive patch test reactions to the HIVAS extract. Testing with a dilution series of PHL revealed positive reactions down to 8.1 ng in selected patients (Paulsen et al., 2007). The clinical results show that some feverfew-allergic patients are sensitive to airborne fractions of feverfew. Furthermore, the detection of PHL from the particle-containing fraction in allergenic amounts is strong evidence of PHL as being the allergen responsible for airborne Compositae dermatitis caused by feverfew. Consequently, the allergens responsible for airborne Compositae dermatitis are likely to be due to the release of small plant particles containing allergenic sesquiterpene lactones. The results also suggests that the responsible airborne allergens from plant species not belonging to Compositae (Asteraceae) are probably also in many cases due to non-volatile allergens released via small plant particles.

References
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