

Development of Anti-allergenic Compound for Durability of Automotive Seat Fabric

Rie HAYASHI*

ABSTRACT

Mite and cedar pollen allergens can be indicated as the main allergens that are carried into automobile passenger cabins, for example by adhering to the clothes of vehicle occupants. An allergen-reducing seat fabric has been developed that displays good deactivation performance against these allergens, and is resistant to the friction, environmental aging, and other severe conditions characteristic of automobiles.

In order to realize this performance, optimal materials were selected from among multiple anti-allergenic compounds. In addition, attention was paid to the compounding ratio, particle size, binding agent, and coating method in order to produce a seat fabric conforming to performance targets.

Tests of the efficacy of the seat fabric in relation to allergens other than cedar pollen indicated that it is effective in reducing allergens throughout the year.

1. Introduction

The incidence of allergies is increasing in Japan, and the rate of allergies affecting the eyes and nose is particularly high⁽¹⁾. In addition, an increasing concern with health and personal comfort is also generating large numbers of proposals for value-added technologies possessing functions that consider the health and comfort of passengers in automobile cabins.

High-performance allergen-free deodorizing air conditioner filters that have already been mass-produced have the function of reducing allergens in automobile cabins. These filters are able to reduce the number of allergens entering the vehicle via air from the outside, but are unable to reduce allergens that are carried into the vehicle, for example substances adhering to occupants' clothes. The allergens entering the vehicle by this path are not restricted to pollen, but also include mite allergens, which produce eye and nose allergies. These allergens accumulate in particularly high quantities on the seats (Fig. 1).

The research discussed in this paper set out to increase occupant comfort in vehicle cabins by developing an anti-allergenic compound that would be effective in deactivating (reducing) various allergens over the course of the year, and applying this compound to automotive seat covers without affecting durability or the commercial appeal and functionality of the seat assembly itself.

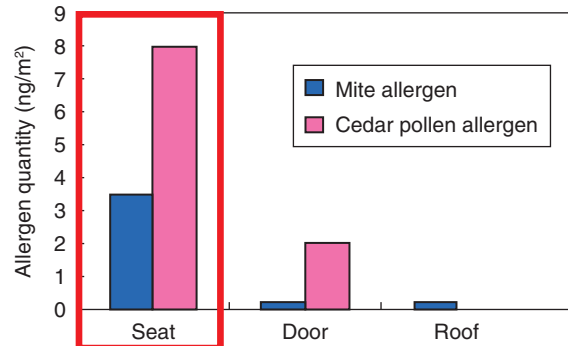


Fig. 1 Mite and cedar pollen allergen count on automotive interior fabrics

2. Anti-allergenic Compounds

In the standard mechanism of generation of allergy symptoms, contact occurs between antibodies adhering to mast cells and allergens (antigens), producing an antibody-antigen reaction (Fig. 2); this results in the release of histamines and other inflammatory substances that stimulate the nerves and blood vessels, and produce allergic symptoms⁽²⁾.

Anti-allergenic compounds are substances that control the reaction between allergens and antibodies in the body by adsorbing allergens and denaturing them by acting on their protein structures.

* Automobile R&D Center

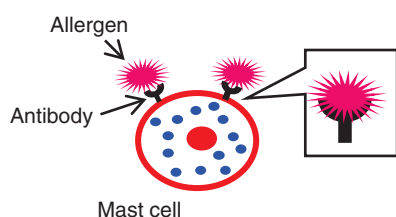


Fig. 2 Mechanism of antigen-antibody reaction

3. Development Goals

The application of conventional anti-allergenic compounds to automotive seat fabrics presents a variety of issues, including restrictions on the allergens targeted by the compound due to the effect of its coloration and other factors, decline in the performance of the compound due to the internal environment of the vehicle cabin or friction, and decline in the attractiveness of the fabric as a result of water marks or other issues during assembly.

The targets set for the allergen-reducing seat fabric developed in the research discussed here were therefore to address the issues described above while fulfilling the performance demands made on automotive fabrics.

3.1. Setting of Targets for Deactivation Performance

The research took mite and cedar pollen allergens, in relation to which there is a high general need for relief, as its target allergens, and set deactivation performance targets based on conditions assumed for a complete vehicle.

In the case of mite allergens, the WHO has established threshold values for the appearance of symptoms. The performance target for the allergen-reducing seat fabric was set as a deactivation rate (reduction rate) such that, commencing with the amount of mite allergens discovered in a complete vehicle, the amount would be below the WHO threshold value for symptoms when the fabric had been exposed overnight.

For cedar pollen allergens, the rate of 10 grains per cm^2 , which has been set by Japan's Ministry of the Environment as the maximum threshold for what is considered to be low levels of pollen, was employed as a reference, and the target for the deactivation rate was set such that the amount of cedar pollen on the seat fabric would always correspond to 10 grains/ cm^2 or less.

3.2. Setting of Durability Targets

The target for the allergen-reducing seat fabric was to maintain a high level of deactivation performance following automotive durability tests involving factors including severe environmental conditions and friction. Following this, the optimal treatment method, binding agent, and other elements were studied from the

perspectives of durability, uniformity of coverage, and mass producibility.

3.3. Maintaining Commercial Appeal of Fabric during Seat Assembly

Specifications were examined to help ensure a uniform coverage of the entire seat fabric in order to boost the performance of the anti-allergenic compound without any reduction of the commercial appeal of the seat cover during seat assembly due to color change or whitening.

3.4. Study of Effect on Allergens other than Mite or Cedar Pollen Allergens

The effect of the allergen-reducing seat fabric in relation to cypress and ragweed pollen allergens was also tested in order to verify its year-round effectiveness in reducing allergens occurring in Japan.

4. Basic Specifications of Allergen-reducing Seat Fabric

4.1. Specifications of Anti-allergenic Compound

To produce the anti-allergenic compound used in this research, a selection was made from among some tens of candidate types that were colorless, highly water-resistant, and stable in response to heat, light and other environmental conditions. From these, an aromatic polymer with hydroxyl groups and zirconium oxide were selected for blending based on their ability to satisfy the development targets indicated in Chapter 3 for both mite and cedar pollen allergens (Fig. 3).

In addition, the specifications were set for a relatively low average particle size of between $0.8\ \mu\text{m}$ to $1.0\ \mu\text{m}$ in order to maintain the stiffness and stretchability of the fabric (factors that affect the commercial appeal of the seat assembly) during the fabric treatment process, and to help ensure that a high level of deactivation performance could be achieved while using a minimal amount of the compound by increasing the amount of contact between allergens and the anti-allergenic compound.

4.2. Specifications of Binding Agent with Consideration of Durability

A binding agent was added to fix the anti-allergenic compound to the seat fabric and help prevent it from being

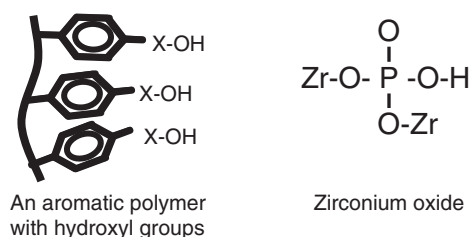


Fig. 3 Structure of anti-allergenic compounds (image)

Table 1 Test results for binder resin

Kind of binder resin	Compatibility with anti-allergenic treatment	Chalk mark resistance	Flame resistance
Polyester resin	○	○	○
Polyurethane resin	○	×	×
Acrylic resin	○	○	×
None	—	×	○

○: OK, ×: No good

rubbed off due to friction, for example from occupant entry and exit. Based on the results of a study of different types of binding agent, a polyester resin able to satisfy performance demands including flame resistance and chalk-mark resistance was selected (Table 1).

4.3. Method of Treatment of Seat Fabric

As the method of treatment, the project employed the dipping method, generally employed as a resin treatment method for automotive seat fabrics. The selection of this method made it possible to treat the entire seat fabric with the anti-allergenic compound, thus helping to enable the realization of a high level of deactivation performance; its use in combination with the binding agent also increased durability.

Figure 4 shows an image of the treatment process, and Fig. 5 shows scanning electron microscope images of the seat fabric before and after treatment.

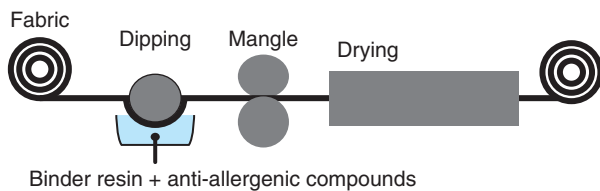


Fig. 4 Processing method for seat fabric

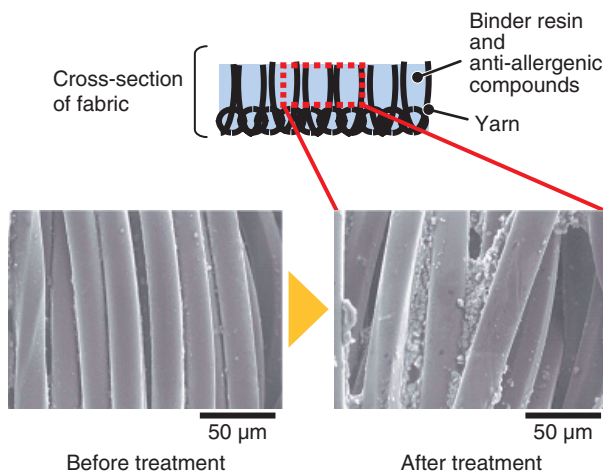


Fig. 5 SEM photograph of seat fabric

Table 2 Test conditions for ELISA

Kind of allergen	Test piece size	Allergen concentration
Mite	25 cm ²	1.575 ng/ml
Cedar pollen		0.325 ng/ml

5. Results of Performance Verification

5.1. Deactivation Characteristics for Mite and Cedar Pollen Allergens

The ELISA method⁽²⁾, a generally employed measurement method, was used in the evaluation of allergen deactivation performance. Measurements were conducted under the conditions shown in Table 2. The conditions were set with reference to the amounts of allergens accumulating in an actual vehicle, as shown in Fig. 1.

As Fig. 6 shows, the seat fabric achieves a high deactivation rate of 97% or more against both mite and cedar pollen allergens.

5.2. Durability as an Automotive Seat Fabric

A variety of durability tests were conducted to study the deactivation performance of the seat fabric, in order to determine whether it would lose its effectiveness under severe automotive environmental conditions (heat, humidity, light) (Figs. 7-9).

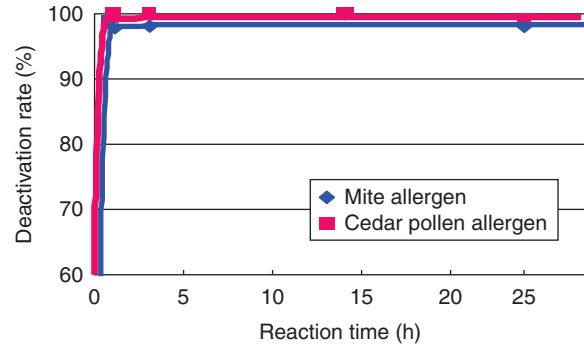


Fig. 6 Test results for deactivation rate

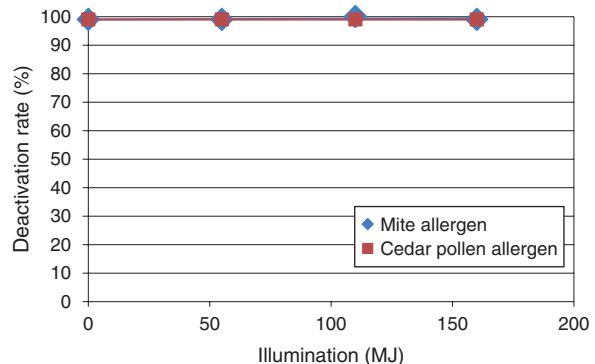


Fig. 7 Test results for deactivation rate after light resistance

It was demonstrated that the allergen-reducing seat fabric maintained an allergen deactivation performance even under severe automotive conditions. Turning attention to the usability of the seats, the allergen deactivation performance of the fabric was also tested following abrasion test using a Taber abrasion tester and durability tests focusing on entry to and exit from the seat assembly (Figs. 10 and 11).

The results of these tests indicate that the seat fabric displays good allergen deactivation performance not only

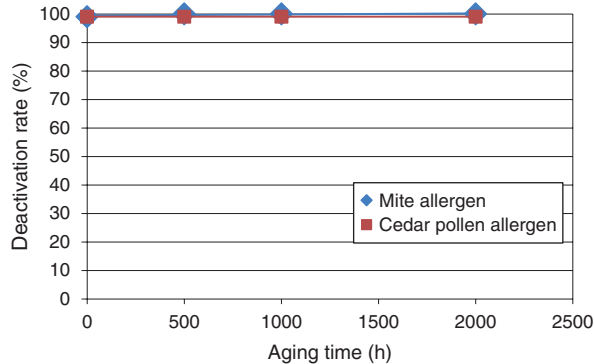


Fig. 8 Test results for deactivation rate after heat and humidity resistance

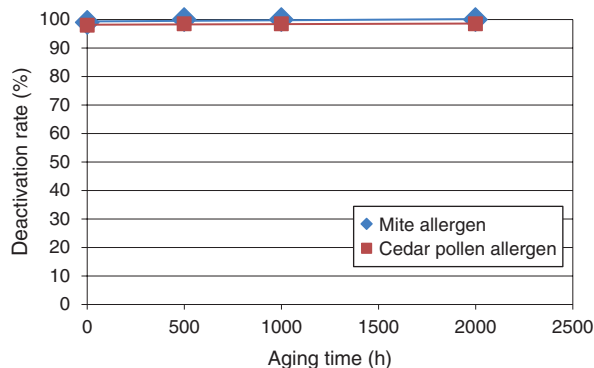


Fig. 9 Test results for deactivation rate after heat resistance (100°C)

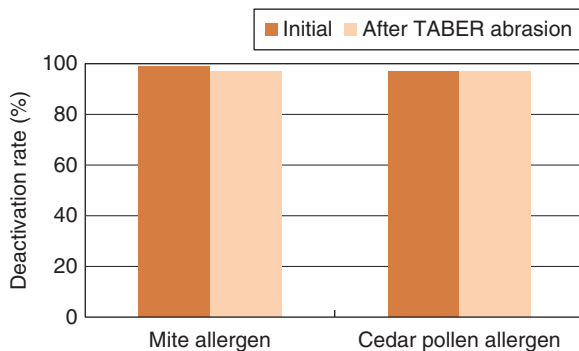


Fig. 10 Test results for deactivation rate after TABER abrasion (3000 cycles)

Table 3 Test results for seat fabric

Item	Non-process	Process
Constant elongation (%)	23/22	25/21
Tensile elongation (%)	93/108	103/106
Tearing strength (N)	218/173	188/155
Stiffness (mm)	33	39
Color fastness (grade)	4.5	4.5
Light resistance (grade: color change)	4.5	4.5
Heat resistance (grade: color change)	4.5	4.5
Heat and humidity resistance (grade: color change)	4.5	5.0

Table 4 Seat ASSY appearance

Seat ASSY appearance	Results
Chalk mark	None
Water mark	None
Wrinkle	None
Yarn breakage	None

initially, but also following testing under a variety of durability testing conditions set for automotive seat fabrics.

5.3. Verification of Fabric Unit Performance and Commercial Appeal of Appearance of Seat Assembly

It remained necessary for a product with the anti-allergenic compound treatment to satisfy performance and commercial appeal demanded for the seat fabric and the seat assembly, and these factors were therefore verified.

Table 3 shows the results of tests of generally demanded automotive seat fabric performance parameters (strength characteristics, resistance to color change or fading in response to environmental factors, and others). Standard performance parameters for the treated fabric are at the same level as for untreated fabric, and there is virtually no decline in elongation or strength in the treated fabric.

With regard to the appearance of the seat assembly using the seat fabric treated with the anti-allergenic compound, as Table 4 indicates, the assembly maintains the same appearance as a seat assembly using untreated fabric, with

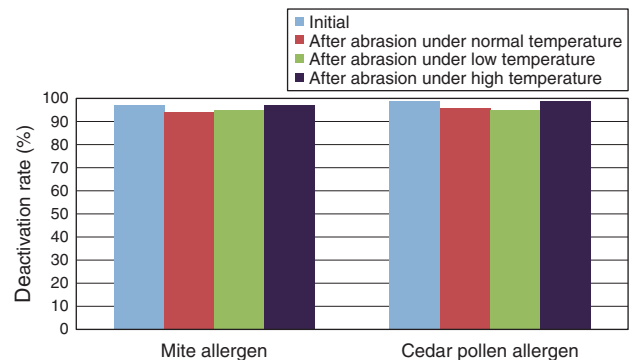


Fig. 11 Deactivation rate after ingress and egress durability

no issues such as chalk marks or water marks.

Plain black fabrics were used in this study in order to facilitate the checking of the appearance of the seat assemblies.

5.4. Verification of Effect in Relation to Allergens other than Mite and Cedar Pollen Allergens

Other than mite and cedar pollen allergens, eye and nose allergies in Japan are also produced by cypress pollen, which is spread in spring, and ragweed pollen, which is spread from summer to fall^{(2), (3)}. The deactivation performance of the treated fabric in relation to these allergens was also tested. The results of these tests are shown in Fig. 12, and demonstrate that the developed seat fabric also displays good deactivation performance in the case of cypress and ragweed pollen. This indicates that the allergen-reducing seat fabric developed in this research will possess a high level of efficacy throughout the year (Fig. 13)^{(2), (4)}.

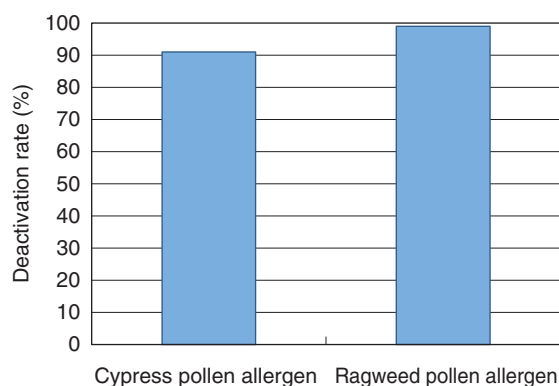


Fig. 12 Test results for deactivation rate of cypress and ragweed pollen allergens

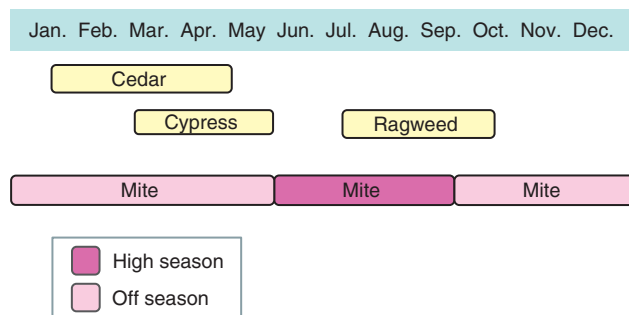


Fig. 13 Terms of pollen scatter in Japan

6. Conclusion

The research discussed in this paper developed an allergen-reducing seat cover with consideration of the durability and commercial appeal of automotive seat assemblies.

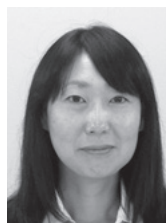
- (1) A seat fabric specification that displays good deactivation performance against multiple allergens, including cypress and ragweed pollen allergens in addition to mite and cedar pollen allergens, was developed through the blending of two types of anti-allergenic compound.
- (2) The selection of an optimal binding agent and treatment process resulted in a specification that maintained good deactivation performance when exposed to durability testing conditions as an automotive seat fabric.
- (3) Refinement of the size of the particles in the anti-allergenic compound and the uniform treatment of the entire surface of the fabric achieved through the use of the binding agent helped enable the developed fabric to maintain the stretchability, stiffness, and resistance to chalk marks necessary from the perspective of the commercial appeal of the appearance of the seat assembly.

The allergen-reducing seat fabric developed in this research has been applied in allergy-free seats in the N BOX. This technology for realizing added functionality in seat fabrics is expected to have wide-ranging applications as a method of increasing commercial appeal.

References

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■ Author ■



Rie HAYASHI