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Correlations between Interior Materials and Allergen Reproduction in Homes

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In Thailand, allergic rhinitis and asthma are major public health problems and are the most prevalent among all types of allergies. The number of people suffering from allergic rhinitis has been increasing every year, and house dust mites are one of the most common triggers of allergic rhinitis and asthma. Studies show that simultaneous control of indoor air temperature and humidity reduces the number of house dust mites. Since dust mites inhabit a single surface throughout their life cycle, the purpose of this research is to study how each interior material affects the number of dust mites under different indoor climate conditions. The study was conducted from July to mid-September 2019 and took place in two connecting rooms in a condominium located in the Pathumwan area of Bangkok's central business district. Dust mites were released on 15 interior surfaces. Every two weeks the number of living and dead dust mites were counted and recorded. The samples were prepared in two sets and placed in two different indoor climate rooms. The temperature and relative humidity in room one was controlled at all times, set to 25°C (± 2°C) and 50% (± 3%), which is the climate that reduces the dust mite reproduction rate. Whereas the temperature and relative humidity was not controlled in the other room

during the study period. The average indoor temperature in the uncontrolled room was 28°C and the average indoor relative humidity was 69%. The results of the study showed that dust mite survival rate varied by material. In dissimilar climates, the same material resulted in differing dust mite survival rates. Therefore, in order to efficiently control the number of mites in a house, there is a need to not only control indoor climate, but also to consider the interior material used in the room.

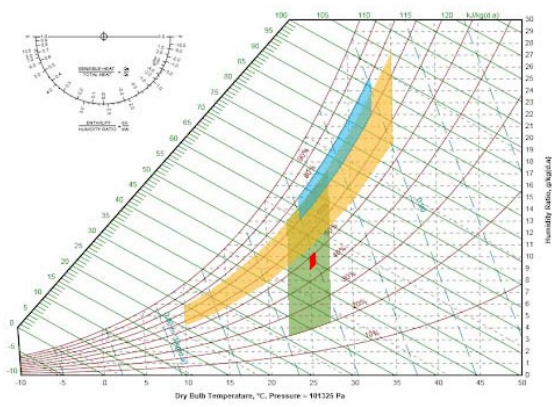
Key words: *Allergen Reproduction, Allergic Rhinitis, Interior Material, Healthy home, Allergen-free material.*

Introduction

Nowadays, the number of people with allergies is increasing worldwide. In Thailand, it has been increasing by 3 to 4 times over the past 20 years, while 25% to 30% of these patients have allergic rhinitis. (Assanasen, 2010). The causes of the disease are both heredity and environmental factors, including climate, living behaviour, building systems, interior materials, and furniture (Turner, 2005). Although allergic rhinitis is not a severe illness, it does reduce a patients' quality of life.

Dust mites are the allergens found in most respiratory allergies. It has been found that the bodies and droppings of dust mites are the source of many allergens (Arlian LG, 1987) (Tovey ER, 1981). The dust mites associated with respiratory allergies are Dermatophagoides pteronyssinus (*Dp*.) and Dermatophagoides farinae (*Df*), whose life cycles are divided into five phases - egg, larva, protonymph, tritonymph, and adult. The rate of reproduction is influenced by the relative humidity and the temperature of the environment in which the dust mites live (BJ, 1998). Dust mites thrive at temperatures between 22 - 25°C, with a relative humidity of 75-80%. However, environments and dust mite sub species can cause significant variations (MJ., 1992; 16).

Dust mites attach themselves to large dust particles (10-30 microns). Therefore, they cannot be suspended in air for extended periods. After falling to the ground, dust mites live on one surface material and rarely migrate throughout their lives (Peyton A. Eggleston, 2005).
The experiment was conducted in two connecting rooms in a condominium located in Pathumwan district, one of fifty central business districts in Bangkok, where population density and air pollution are high. During the experimental period, there were no occupants in the rooms.



HDM high growth and survival zone
RH 55-75%, T10-35°C
Human comfort zone
RH 20-75%, T 22-27°C
Human comfort zone in closed system
RH 45-50%, T 25-25.5°C
Average weather in Bangkok
RH 70 - 80%, T 24 - 32°C

Conditions were created in the control room that limit the amount of dust mite propagation determined to be unsuitable for sustaining a dust mite population and propagation. Average weather conditions in Bangkok are as follows: HDM high growth and survival zone RH 55-75%, T10-35°C (Larry G. Arlian P 'a'-M', 2001); human comfort zone RH 20-75%, T 22-27°C (Olgyay, 1963); human comfort zone in a closed system RH 45-50%, T 25-25.5°C (Boonyathikan, 1999) and the average weather condition in Bangkok RH 70 - 80%, T 24 - 32°C (Greetha Moungthong, 2014). Therefore, the optimum conditions for controlling dust mites for rooms with occupants are 25°C with a relative humidity of 50%. Both the temperature and humidity must be controlled at all times, even if there are no people living in the room, because the relative humidity exceeds 58% for at least 2 hours per day, dust mites would survive and propagate (Greetha Moungthong, 2014).

However, in Thailand, where the climate is mostly hot and humid throughout the year, maintaining indoor air conditions to meet the ideal requirements at all times is both difficult and costly. Therefore, if the interior materials and furniture on which dust mites live can reduce the dust mite reproduction rate, then controlling and choosing these materials is less complex and less expensive in the long term, since decorative material selection is one of the existing steps in the interior design process.

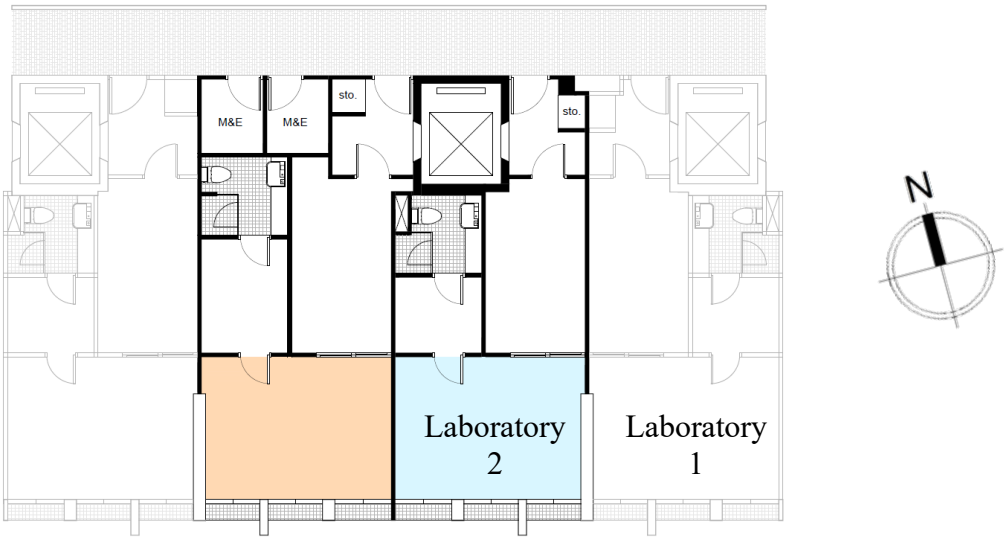
This experiment was designed to study how each interior finishing material and furniture upholstery affects the number of dust mites and the changes that occur under different indoor climates. And finally, the study aims to find interior materials that are suitable for patients with respiratory allergies.

Methods

Laboratory

The experiment was carried out in two laboratories, one with climate control and the other without climate control. During the duration of this study, neither room had occupants in order

to reduce the variables that could affect the rate of dust mite growth and reproduction, such as usage behaviour, cleaning characteristics, smoking, or domestic pets (BJ., 1998) (Pattaraporn Piwong, 2014).



- Laboratory 1: The Climate Controlled Room had indoor temperature and relative humidity controlled at 25°C (± 2°C) and 50% (± 3%) at all times throughout the study. The adjustment was controlled by air conditioning and a Precise Climate Controller, with both temperature and relative humidity recorded every hour by a temperature and humidity logger. The indoor climate adjustment began one week prior to the experimental period to ensure the stability of the laboratory climate.
- Laboratory 2: The Non-Climate Controlled Room was a room that was not equipped with any temperature or relative humidity controls. Both temperature and relative humidity in the room were recorded every hour by a temperature and humidity logger.

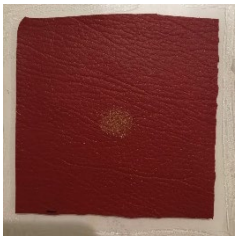
Experimental Material

The materials used in this study are materials frequently used in interior decoration and furniture. The 15 materials include:

1. Soft surface material group

1.1 Cotton

1.2 Cow Leather



1.3 Carpet

1.4 X-Allergen Carpet

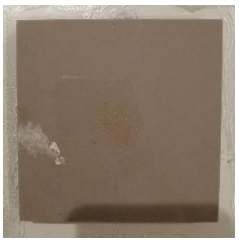
2. Hard surface material group

2.1 Oakwood

2.2 Plywood

2.3 MDF Board

2.4 Gypsum Board



2.5 Cement Board

2.6 Ceramic Tile

2.7 Marble

2.8 Acrylic Stone

2.9 PVC

2.10 Stainless Sheet

2.11 Laminate

Table 1: Characteristics of all 15 materials used in the experiment.

Material	Thickness (mm)	Weight (g)	Application in interior decoration work			
			Furniture	Floor	Wall	Ceiling
1. Soft surface material						
1.1 Cotton	0.5	3.0	✓		✓	
1.2 Cow Leather	10.0	6.0	✓		✓	
1.3 Carpet	4.0	48.0	✓	✓		
1.4 X-Allergen Carpet	4.0	36.0	✓	✓		
2. Hard surface material						
2.1 Oakwood	20.0	140.0	✓	✓	✓	
2.2 Plywood	10.0	96.0			✓	
2.3 MDF Board	10.0	138.0			✓	
2.4 Gypsum Board	9.0	54.5			✓	✓
2.5 Cement Board	9.0	137.0	✓	✓	✓	
2.6 Ceramic Tile	10.0	190.0	✓	✓	✓	
2.7 Marble	20.0	470.0	✓	✓	✓	
2.8 Acrylic Stone	20.0	461.0	✓			
2.9 PVC	1.0	4.0	✓			
2.10 Stainless Sheet	1.2	91.0			✓	
2.11 Laminate	0.5	11.0			✓	

Materials prepared for the experiment were 10cm by 10cm and placed on 15cm by 15cm glass trays. The surrounding area of the trays was coated with pure petroleum jelly to prevent dust mites from escaping.

Experimental Method

Two scoops of mites, *Dermatophagoides pteronyssinus* (Dp), that are related to respiratory allergies (Larry G. Arlian P. A-M., 2001), were used for the experiment. Test trays were separated into two groups and placed in the two laboratories. Every two weeks, three trays of each material type were taken from each room to count the number of living and dead dust mites at The Research and Development Department in Allergies and Immunology, Faculty of Medicine, Siriraj Hospital, Mahidol University. The experiment was conducted for a total of 12 weeks from July to September 2019.

Results

Laboratory 1: Climate Controlled Room

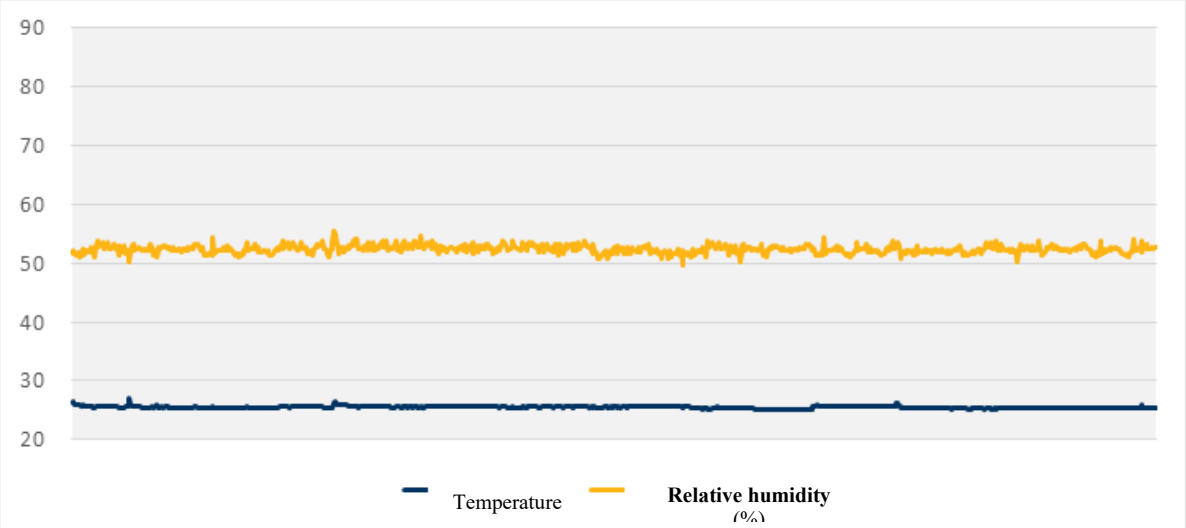
Table 2: shows the average percentage of dust mites that survived each week.

Experimental material	W0	W2	W4	W6	W8	W10
1. Soft surface material group						
1.1 Cotton	100%	2.0%	0.0%	0.0%	0.0%	0.0%
1.2 Cow Leather	100%	0.0%	0.0%	0.0%	0.0%	0.0%
1.3 Carpet	100%	29.0%	3.5%	0.0%	0.0%	0.0%
1.4 X-Allergen Carpet	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2. Hard surface material group						
2.1 Oakwood	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.2 Plywood	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.3 MDF Board	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.4 Gypsum Board	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.5 Cement Board	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.6 Ceramic Tile	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.7 Marble	100%	4.4%	0.0%	0.0%	0.0%	0.0%
2.8 Acrylic Stone	100%	7.7%	0.0%	0.0%	0.0%	0.0%
2.9 PVC	100%	0.7%	0.0%	0.0%	0.0%	0.0%
2.10 Stainless Sheet	100%	1.2%	0.0%	0.0%	0.0%	0.0%
2.11 Laminate	100%	0.0%	0.0%	0.0%	0.0%	0.0%

The results in Table 2 show the average percentage of the number of dust mites that survived each week. In the soft material group, cotton had a percentage showing the average number of dust mites that survived in week 2 at 2.0%, while from week 4 to week 10, the average percentage of dust mites that survived was 0.0%. Cow Leather and X-Allergen Carpet show the average percentage of dust mites that survived was 0.0% from week 2 through week 10. Carpet in week 2 showed a 29.0% survival rate, a 3.5% survival rate in week 4, and 0.0% survival rate from week 6 to week 10. The results of hard surface materials such as Oakwood, Plywood, MDF Board, Gypsum Board, Cement Board, Ceramic Tile, and Laminate show the same results: in week 2 to week 10, the average percentage of dust mites that survived was 0.0%. On marble materials, the average number of dust mites that survived into week 2 was 4.4%, and from week 4 to week 10, the average percentage of dust mites that survived was 0.0%. Acrylic Stone shows the average number of dust mites that survived in week 2 was 7.7%, but from week 4 to week 10, the average percentage of dust mites that survived was 0.0%. PVC shows the average number of dust mites that survived into week 2 at 0.7%, and from week 4 to week 10, the average percentage of dust mites that survived was 0.0%. Stainless

Sheet shows the average number of dust mites that survived into week 2 was 1.2%, while from week 4 to week 10, there was an average percentage of dust mites that survived at 0.0%.

Graph 2. Shows the temperature and relative humidity within Laboratory 1 throughout the experiment period.



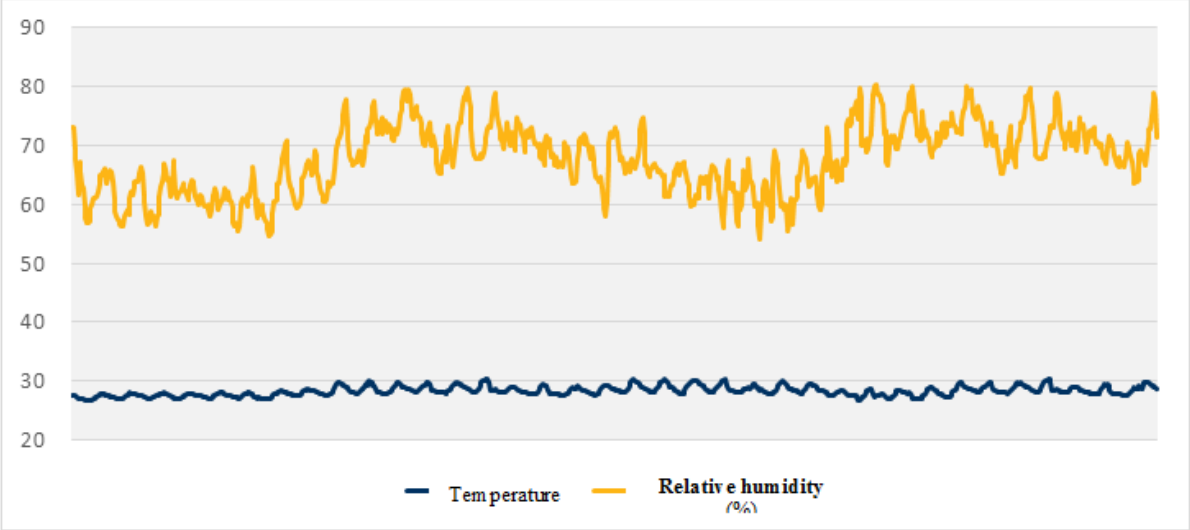
Laboratory 2: Non-Climate Controlled Room

Table 3: Shows the average percentage of dust mites that survived each week.

Experimental material	W0	W2	W4	W6	W8	W10
1. Soft surface material						
1.1 Cotton	100%	49.0%	0.3%	0.0%	0.0%	0.0%
1.2 Cow Leather	100%	20.0%	10.0%	0.0%	0.0%	0.0%
1.3 Carpet	100%	30.9%	11.5%	0.0%	0.0%	0.0%
1.4 X-Allergen Carpet	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2. Hard surface material						
2.1 Oakwood	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.2 Plywood	100%	10.5%	0.0%	0.0%	0.0%	0.0%
2.3 MDF Board	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.4 Gypsum Board	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.5 Cement Board	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.6 Ceramic Tile	100%	2.2%	0.0%	0.0%	0.0%	0.0%
2.7 Marble	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.8 Acrylic Stone	100%	13.4%	5.2%	0.0%	0.0%	0.0%
2.9 PVC	100%	0.0%	0.0%	0.0%	0.0%	0.0%
2.10 Stainless Sheet	100%	14.4%	1.8%	0.0%	0.0%	0.0%
2.11 Laminate	100%	8.7%	0.0%	0.0%	0.0%	0.0%

The second lab was the non-climate controlled room. In the soft material group, cotton showed an average percentage of dust mites that survived in week 2 was 49.0%, in week 4 was 0.3%, and from week 6 to week 10, the average percentage of dust mites that survived dropped to 0.0%. For cow leather, the average percentage of dust mites that survived in week 2 was 20.0%, in week 4 was 10.0%, and from week 6 to week 10, the average percentage of dust mites that survived was 0.0%. X- Allergen carpet had an average percentage of dust mites that survived at 0.0% from week 2 to week 10. Carpet in week 2 showed 30.9% dust mite survivability, 11.5% at week 4, and 0% survivability from week 6 to week 10. For the results of hard surface materials, including Oakwood, MDF Board, Gypsum Board, Cement Board, Marble, and PVC, the results were the same. From week 2 to week 10, the average percentage of dust mites that survived was 0.0%. Plywood showed a 10.5% average dust mite survival rate in week 2, while from week 4 to week 10, the average percentage of dust mites that survived was 0.0%. The average percentage of dust mites that survived to week 2 on Ceramic Tile was 2.2%, and from week 4 to week 10, the average percentage that survived was 0.0%. Acrylic Stone showed an average percentage of dust mites that survived in week 2 at 13.4%, with week 4 at 5.2%. After that, week 6 to week 10 saw the average percentage of dust mites that survived drop to 0.0%. Stainless Sheet had an average of dust mites that survived in week 2 at 14.4%, 1.8% at week 4, and 0.0% for week 6 to week 10. Laminate had an average dust mite survival rate of 8.7% in week 2, which dropped to 0.0% in week 4 to week 10.

Graph 3. Shows the temperature and relative humidity in the laboratory 2 throughout the experiment.



Discussion

Controlling both temperature and relative humidity helps reduce the survival rate of dust mites. From the experiment, it was found that the average survival rate of dust mites in the climate-

controlled room was lower or equal to the room without climate control. That is, in the overall room, there are no restrictions on the types of decoration materials, temperature, and humidity control that can help reduce the number of allergens in that room.

Table 4: shows the average percentage of dust mite survival rates in laboratory 1 and laboratory 2

Laboratory	W0	W2	W4	W6	W8	W10
Laboratory 1	100%	3.0%	0.2%	0.0%	0.0%	0.0%
Laboratory 2	100%	9.9%	1.9%	0.0%	0.0%	0.0%

Each type of finishing material has specific properties that affect the survival rate of dust mites, and even on the same materials, but in different environments, they give different results. The suitability of habitat facilitates the survival of dust mites on the surface of the material as a specific feature of the material. This property is affected by the temperature and relative humidity in the room.

Table 4 shows the average percentage of dust mite survival in laboratory 1 and laboratory 2 on all 15 materials. It was found that for laboratory 1, in week 2, the average percentage of dust mite survival was 3.0%, in week 4 the average was 0.2%, and in weeks 6-10 the average was 0.0%. The results from all 15 materials in the 2nd laboratory show an average percentage dust mite survival rate in week 2 of 9.9%, in week 4 of 1.9%, and in weeks 6-10, an average of 0.0%. When comparing the average dust mite survival rate of laboratory 1 to that of laboratory 2, with limited materials (X-Allergen Carpet, Oakwood, MDF Board, Gypsum Board, Cement Board, Marble, Acrylic Stone, and PVC), it was found that the average survival rate of dust mites in data from laboratory 1 is higher than or equal to the average of data set from laboratory 2. From this comparison, it can be concluded that under the conditions of this experiment, the use of the right materials can reduce the survival rate of dust mites better than only controlling for temperature and relative humidity.

Table 5: shows the classification of finishing materials according to the suitability of being a habitat for dust mites, based on the level of survival of dust mites in laboratory 1 and laboratory 2.

Material	Survival Rate Level		Group
	Laboratory 1	Laboratory 2	
1. Soft surface material			
1.1 Cotton	Low	High	Group 1
1.2 Cow Leather	Low	High	Group 1
1.3 Carpet	Low	High	Group 1
1.4 X-Allergen Carpet	Low	Low	Group 3
2. Hard surface material			

Material	Survival Rate Level		Group
	Laboratory 1	Laboratory 2	
2.1 Oakwood	Low	Low	Group 3
2.2 Plywood	Low	High	Group 1
2.3 MDF Board	Low	Low	Group 3
2.4 Gypsum Board	Low	Low	Group 3
2.5 Cement Board	Low	Low	Group 3
2.6 Ceramic Tile	Low	High	Group 1
2.7 Marble	High	Low	Group 2
2.8 Acrylic Stone	Low	High	Group 1
2.9 PVC	High	Low	Group 2
2.10 Stainless Sheet	Low	High	Group 1
2.11 Laminate	Low	High	Group 1

Table 5 shows the classification of decorative materials according to the suitability of being a habitat for dust mites, according to the level of survival of dust mites in the first and second lab. From the experiment, we can group decorative materials according to the characteristics of being suitable as a habitat for dust mites, divided into 3 groups, as follows;

In Group 1, the survival rate of dust mites was higher in the controlled room on the Cotton, Cow Leather, Carpet, Plywood, Acrylic Stone, Ceramic Tile, Stainless Sheet and Laminate materials.

In Group 2, the survival rate of dust mites was higher in the non-controlled room on the materials Marble and PVC.

Group 3 had a low survival rate of dust mites in both the controlled and non-controlled rooms on the materials X-Allergen Carpet, Oakwood, MDF Board, Gypsum Board, and Cement Board.

Therefore, controlling for temperature and relative humidity, in addition to being difficult to do in a weather climate such as Bangkok, does not reduce the survival rate of dust mites for rooms that use certain types of materials (Group 3) for decoration. However, with soft surface materials, there is a tendency for dust mites to survive longer, as evidenced in laboratory 2, where dust mites on soft surface materials had longer survival rates.

Conclusion

Although controlling the temperature and relative humidity can help reduce the survival rate of dust mites, choosing the right materials makes this process more effective.

This study found that various types of interior materials have specific properties that affect the survival time of dust mites. Because dust mites grow and spread on the surface of these materials throughout their lives, the selection of materials that have high resistance to the survival of dust mites reduces their number and thus lowers the number of allergens in a room.

In addition, it was found that the survival rate of dust mites on soft surface materials tends to be higher than that of dust mites in the hard surface material group. Soft surface materials are more conducive to dust collection, resulting in more dust, including dust mites, than are found on hard surface materials.

Therefore, materials suitable for decorating the rooms of patients with respiratory allergies in the Bangkok Metropolitan area should provide a low dust mite survival rate, regardless of whether the environment is controlled or not. That is, the most suitable materials come from the third group in this experiment: X-Allergen Carpet, Oakwood, MDF Board, Gypsum Board, and Cement Board.

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