Presented at 1998 Pan-American Workshop on
Commercialization of Advanced Oxidation Technolgies
London, Ontario, Canada, June 27-30,1998

Destruction of Dust Mite Allergens using Photech® - Photocatalytic Technology for Disinfection of Indoor Air

C. Beaudreau, S. K. Hingorani*, T. K. Goswami

Universal Air Technology

12085 Research Drive, Alachua, FL 32615

and

D. Y. Goswami

Solar Energy & Energy Conversion Laboratory

Department of Mechanical Engineering

University of Florida,Gainesville, FL 32611

Abstract: Some 15-25% of the population show an allergic response to common environmental antigens. Eighty to 90% of this group will test positive to dust mite antigens. Some of the common dust mite antigens are *Der p I, Der p II* and *Der f I*. The more resistant to denaturation antigen *Der p II* was selected to test the ability of the patented photocatalytic oxidative process of Universal Air Technology to inactivate an antigen. A specific Enzyme Linked Immuno-sorbent Assay (ELISA) was used to follow the loss of activity. A rapid loss of activity was demonstrated. The ability of this process to inactivate this dust mite antigen may represent an effective way to destroy the antigenicity of a common family of antigens.

Key words: Antigens; Photocatalytic; Oxidation; Denaturation; Dust mites; Allergic.

INTRODUCTION

The allergic character of household dust is, to some extent, caused by allergens originating from mites of the genus *Dermatophagoides*. There are ten species of dust mites that have been identified of which four predominate, namely *Dermatophagoides pteronyssinus*, *D. farinae*, *D. microceras* and *Euroglyphus maynci* (Platts-Mills *et al.*, 1992). In the United States *Dermatophagoides pteronyssinus* and *D. farinae* are the two most usual species that are seen (Janko et al., 1995). *D. pteronyssinus* flourishes favorably in moist, humid environments, while *D. farinae* prefers drier environments. The specific causative agents for the allergic reaction are found in mite feces and body fragments of dead mites. Some of the most common dust mite antigens involved in clinically observed allergic reactions to dust mites are *Der p I*, *Der p II* and *Der f I* (de Blay *et al.*, 1991). It has been reported that 15-25% of people show an antigenic response to common environmental antigens (Platts-Mills *et al.*, 1995; Rawle *et al.*, 1984; O'Brien *et al.*, 1992) and 80-90% of these people show an antigenic response to the mite antigen D*er p II (*Platts-Mills and Chapman, 1987; Lanzavecchia *et al.*, 1983; O'Hehir *et al.*, 1993; van Nerven *et al.*, 1993).

Detoxification and disinfection of indoor air by photocatalytic oxidation has been reported in the literature (Goswami, 1995, Goswami *et al.* 1997). However, no study has been reported on inactivation of dust mite antigens by photocatalysis.

In the present study, preliminary experiments were conducted at Universal Air Technology (UAT) to determine the feasibility of photocatalytic technology for inactivating the dust mite antigen *Der p II* and thereby eliminating its allergic potential. Of the two most common antigens of *D. pteronyssinus* (Lombardero *et al.*, 1990), *Der p II* antigen resists

---

* Author to whom all correspondence should be sent

denaturation more tenaciously than *Der p I*. Since *Der p II* antigen exists in conjunction with *Der p I* antigen, resists denaturation, and contributes to allergies among humans, any procedure which effectively inactivates *Der p II* antigen might be expected to similarly effect *Der p I* and *Der f I* antigens. Photocatalytic oxidation of the *Der p II* antigen thus would represent an expedient and cost effective way to destroy the antigenicity of a common family of antigens.

MATERIALS AND METHODS

Dust mite extract containing the *Der p II* antigen was obtained from Greer Laboratories, Lenoir, NC. *Der p II* ELISA reagents were purchased as a kit from Indoor Biotechnologies, Charlottesville, VA. Streptovidin-Peroxidase, Bovine Serum Albumin, Tween 20 and 2,2'-azino-di-(3-ethylbenzthiazoline sulphonic acid) were purchased from Sigma, St Louis MO. Immulon II flat bottomed ELISA plates (Dynatech, Alexandria, VA) were used. The catalyst used (Titanium dioxide based) was proprietary UATC-10. Other necessary reagents were purchased from usual sources.

The experimental setup included.

Reaction Vessels

The reaction vessels were open Pyrex petri dishes (15x100 mm). The reactors were loaded with deionized water (DI), *Der p II* antigen and UATC-10 catalyst as required.

Reactor Chamber

The Reactor Chamber used was a closed wooden box (50x 50 x 45 cm) equipped with 6 blacklight blue lamps of 15 Watts each. The reactor vessels were placed on the rotating platform, which was approximately 20 cm from the light source, at which point, the UV irradiation measured as 2 W/m^2.

Reactor Setup

An experimentally determined amount of dust mite extract was used so that 100 µl of a 1/5 dilution in 1% Bovine Serum Albumin-Phosphate Buffered Saline-0.05% Tween 20 (1%BSA-PBS-T) produced ELISA results that fell within the standard curve range (5-200 ng/ml).

Three experimental conditions were run.

1. (DI) water, *Der p II* antigen, 0.01% UATC-10 catalyst, run in the presence of UV light (photocatalytic oxidation process).
2. DI water, *Der p II* antigen, run in presence of UV light (represents the photolysis control).
3. Same as 1 above except run in the absence of UV light (representing the dark control).

All reaction mixtures had a final volume of 25 ml.

Sampling and Analysis

One hundred microliter samples were taken versus time and stored at 4°C as 1/5 dilutions in 1%BSA-PBS-T. One hundred microliter aliquots of the 1/5 dilution were assayed by ELISA as described (de Blay et al., 1991). Experiments were repeated three times to confirm repeatability.

RESULTS

Figure 1 shows the results of the above experiments. All of the results were calculated as percentage of *Der p II* antigen remaining in the reaction mixture at the given time point. From the figure it can be clearly seen that there is no inactivation of the antigen in the presence of the catalyst and no light (dark control run). In the case of UV light and no catalyst (photolysis) there appears to be a slight inactivation. In the complete reaction mixture of antigen, catalyst and

ultraviolet light (UAT photocatalytic process) there is a marked reduction of active antigen versus time.

DISCUSSION

The amino acid sequence of *Der p II* is known (Chua., et al., 1990) and it is also known that it has four epitopes (Platt-Mills et al., 1992). There are three disulfide bridges that are necessary for its full antigenic activity. Site-directed mutagenesis has been used to show the relative effect of breaking the individual bridges (Smith and Chapman, 1996). It can not be determined from this study what intermediates are formed. Further experiments are planned to see if the intermediate products of the oxidative inactivation can be determined or if the antigen is completely mineralized.

REFERENCES

Chua, K.Y., Doyle, C.R., Simpson, R.J., Stewart, G.A. and Thomas, W.R. (1990) "Isolation of cDNA coding for the major mite allergen *Der p II* by IgE plaque immunoassay" *International Archives of Allergy and Applied Immunology*, **91**, 118-123.

DeBlay, F., Heymann, P.W., Chapman, M.D. and Platts-Mills, T.A.E. (1991) "Airborne dust mite allergens: Comparison of group II allergens with group I mite allergen and cat-allergen Fel d I, *Journal of Allergy and Clinical Immunonolgy*, **88**, 919-926.

Goswami, D.Y. (1995) "Engineering of Solar Photocatalytic Detoxification and Disinfection Processes", *Advances in Solar Energy*, K. W. Boer, editor, Chapter 3, 165-209

Goswami, D.Y., Trivedi, D., and Block, S.S. (1997), "Photocatalytic Disinfection of Indoor Air", *Journal of Solar Energy Engineering*, 119, 92-96.

Janko, M., Gould, D.C., Vance, L., Stengel, C.C. and Flack, J. (1995) "Dust mite allergens in the office environment", *American Industrial Hygiene Association Journal,* **56,** 1133-1140.

Lanzavecchia, A., Santini, P., Maggi, E., Del Prete, E.F., Falagiani, P., Romagnani, S. and Ferrarini, M. (1983) "In Vitro selective expansion of allergen-specific T cells from atopic patients" *Clinical Experimental Immunology,* **52**, 21-28.

Lombardero, M., Heymann, P., Platts-Mills, T.A.E., Fox, J. and Chapman M.D. (1990) "Conformational stability of B cell epitopes on group I and group II *Dermatophagoides* spp. allergens: effect of thermal and chemical denaturation on the binding of murine IgG and human IgE antibodies" *Journal of Immunology,* **144**, 1353-1360.

O'Brian, R.M., Thomas, W.R., and Wooten, A.M. (1992) "T cell responses to the purified major allergens from the house dust mite *Dermatophagoides pteronyssinus*", *Journal of Allergy and Clinical Immunology,* **89**, 1021-1031.

O'Hehir, R., Verhoef, A., Panagiotopoulou, E., Keswani, S., Hayball, J., Thomas, W.R. and Lamb, J.R. (1993) "Analysis of human T cell responses to the group II allergen of *Dermatophagoides* species: Localization of major antigenic sites" *Journal of Allergy and Clinical Immunology,* **92**, 105-113.

Platts-Mills, T.A.E., and Chapman M.D. (1987) "Dust mites: Immunology, allergic disease and environmental control" *Journal of Allergy and Clinical Immunology,* **80**, 755-775.

Platts-Mills, T.A.E., Sporik, R., Chapman, M.D. and Heymann, P.W. (1995) "The role of indoor allergens in asthma", *Allergy,* **50, suppl 22,** 224-230.

Platts-Mills, T.A.E., Thomas, W.R., Aalberse, R.C., Vervloet, D. and Chapman, M.D. (1992) "Dust mite allergens and asthma: Report of a second international workshop", *Journal of Allergy and Clinical Immunology,* **2:89,** 1046-1060.

Rawle, F., Mitchell, E. and Platts-Mills, T.A.E. (1984) "T cell responses to the major allergen from the house dust mite *Dermatophagoides pteronyssinus,* antigen P1: comparison of patients with asthma, atopic dermataitis and perennial rhinitis", *Journal of Immunology,* **133,** 195-201.

Smith, A.M. and Chapman, M.D. (1996) "Reduction in IgE binding to allergen variants generated by site-directed mutagenesis: Contribution of disulfide bonds to the antigenic structure of the major house dust mite allergen *Der p II.*" *Molecular Immunology,* **33,** 399-405.

Van Neerven, R.J.J., van t'Hof, W., Ringrose, J., Jansen, H., Aalberse, R., Wierenga, E. and Kapsenberg, M. (1993) "T cell epitopes of house dust mite major allergen *Der p II*" *Journal of Immunology,* **151,** 2326-2335.

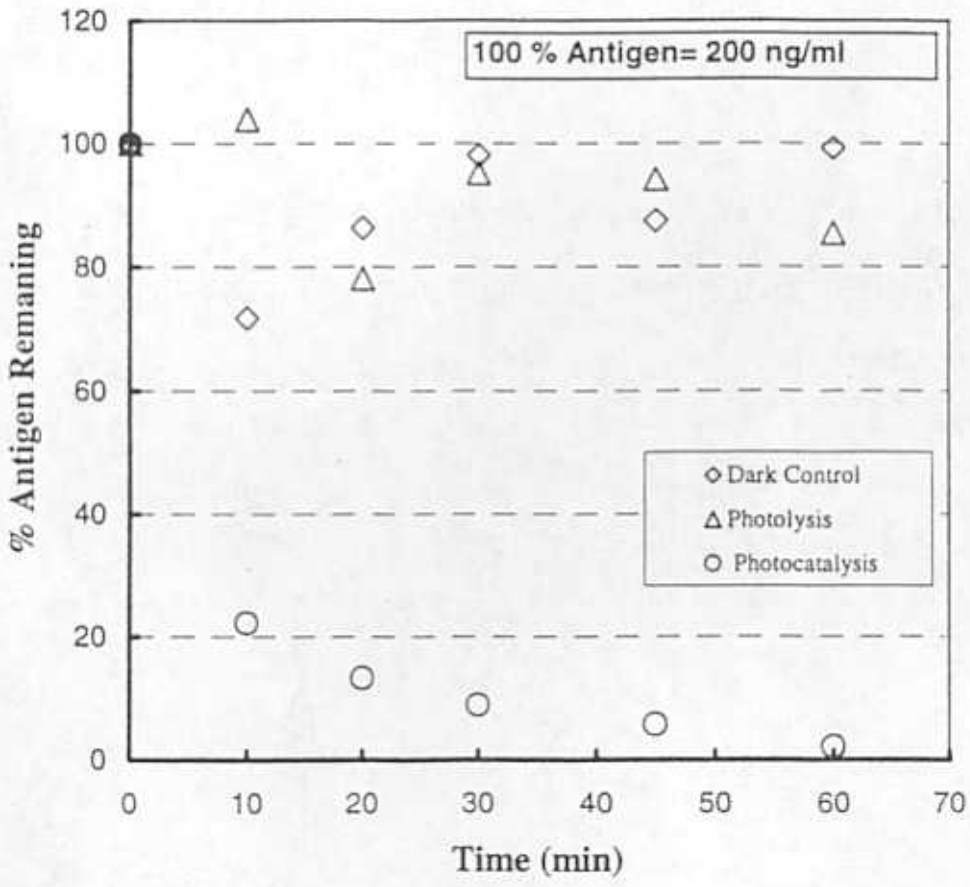

Figure 1 Photocatalytic Inactivation of Der p II