

p-tert-Butylphenol Formaldehyde Resin and Its Impact on Children

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***p*-tert-Butylphenol formaldehyde resin (PTBPFR) is widely used as an adhesive owing to its rapid onset of action, durability, flexibility, and heat resistance. Moreover, because of its tackiness, it is particularly useful as a glue component on both leather and rubber products. Sensitization to this resin has been increasing since the first cases of PTBPFR contact allergy in the late 1950s, and pediatric contact allergy to this resin is a significant problem. *p*-tert-Butylphenol formaldehyde resin has been reported as a leading cause of shoe-associated dermatitis internationally, as well as a cause of allergic contact dermatitis from its use in neoprene wet suits and sports equipment such as shin guards. In summary, patch test screening of both adults and children with PTBPFR is important, given the ubiquitous use of this chemical.**

CONTACT ALLERGY to adhesives is a common problem, accounting for a significant percentage of patients referred to contact dermatitis centers. More specifically, with a prevalence ranging from 3.3% to 11.7%,^{1,2} footwear dermatitis is not an uncommon complaint among patients with allergic contact dermatitis (ACD), especially children.³ Top adhesive allergens include colophony, epoxy, acrylates, and *p*-tert-butylphenol formaldehyde resin (PTBPFR), which gained favor owing to its flexibility, durability, heat resistance, and rapid onset of action.^{4,5} It is important to note that, like the other adhesives listed, sensitization to this resin has also been recognized. More than 50 years ago, Malten⁶ described the first cases of contact allergy to PTBPFR (in 10 cobblers reacting to a shoe adhesive); he then went on to identify both this resin and *p*-tert-butylphenol (PTBP) as separate sensitizers.^{7,8}

p-tert-Butylphenol formaldehyde resin is an alkyl phenol resin formed by combining PTBP and formaldehyde⁹ (Fig. 1). Synonyms for PTBPFR include *para*-tertiary-butylphenol formaldehyde resin,

PTBP formaldehyde, butylphen, 4-(1,1-dimethylethyl)phenol, and 4-*tert*-butylphenol formaldehyde resin.¹⁰

Because of its tackiness, PTBPFR is particularly useful as a glue component on both leather and rubber products.⁹ Table 1 lists common products containing PTBPFR.

Since the first cases of contact allergy to PTBPFR were reported in the late 1950s, sensitization to this resin has been increasing,¹¹ perhaps because of its ubiquitous use. The components of the resin that are the actual sensitizers have been in question for years^{8,12} because PTBPFR is in its macromolecular form when used as an adhesive, and this molecule is thought to potentially be too large to penetrate the epidermis.⁷ Several chemically reactive components of varying molecular weights have been discovered either within the resin or as degradation products.^{8,11} Examples of such components within the resin include PTBP, 2-methylol *p*-tert-butylphenol, 2,6-dimethylol *p*-tert-butylphenol, and *p*-tert-butylcatechol. Degradation products such as 2(3)-*tert*-butyl-4-hydroxyanisole and 3,5-di-*tert*-butyl-4-hydroxytoluene have also been reported to cause sensitization¹¹ (Fig. 2). However, there is no clear association with contact allergy to PTBPFR and to free PTBP,⁷ and the pattern of reactivity of the allergen components of PTBPFR can differ among patients sensitized to PTBPFR.⁸

On par with Malten's initial reports, PTBPFR has been reported as a leading cause of shoe-associated dermatitis internationally,^{13–16} accounting for up to 24.7% of positive patch test results (PPTs), according to the North American Contact Dermatitis Group (NACDG).¹³ This high prevalence places this allergen above many of the other chemicals commonly associated with ACD of the feet (ie, those involved in leather and rubber processing, namely, potassium dichromate, carba mix, thiuram mix, mercaptobenzothiazole, mercapto mix, mixed dialkyl thio-ureas, *p*-phenylenediamine, and black rubber mix). Of note, children and adolescents can place themselves at greater risk for ACD of the feet because of their common practice of wearing shoes without socks.

In addition to playing an important role as a contact allergen in footwear, PTBPFR has also been reported as a cause of ACD associated with a significant number of other uses, such as a plastic bonder in hearing aids.¹⁷ Up to 27% of patients who have otitis externa and use hearing aids react positively when patch tested with earmold components.¹⁸ Additional PTBPFR sources that have been reported to cause ACD are electrocardiography-monitoring

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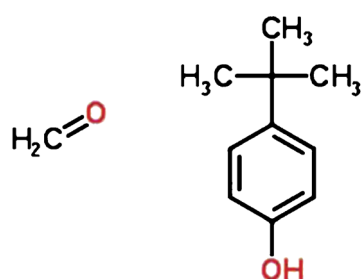


Figure 1. *p*-*tert*-Butylphenol formaldehyde resin.

electrodes,¹⁹ adhesive dressings and labels,^{4,20} and fingernail adhesives.^{7,21}

More recently, PTBPF_R has been frequently recognized as a cause of ACD associated with wet suits and thermal (neoprene) sauna shorts.^{9,5,22} Although thiourea derivatives are classically thought to be a primary source of sensitization to products made of or containing neoprene, PTBPF_R does play a role^{5,22}; in fact, thiourea derivatives and PTBPF_R are touted as the “neoprene cement allergens.” Neoprene is a durable synthetic rubber material resistant to oils, solvents, and extreme climate conditions.²³ Developed in 1930 by DuPont, it was initially used in industrial applications, gaskets, and printing rollers. However, during World War II, as the United States faced a rubber shortage, neoprene production increased; large amounts were used in military applications and for combat attire such as gloves and face masks.²⁴ Neoprene is now widely used in a number of products, from sports items (wet suits), slimming suits, gloves, and footwear to holders and clips for hand sanitizers and insulating covers for canned drinks. PTBPF_R is used in neoprene because of its adhesive qualities.⁵

European prevalence rates of contact allergy to PTBPF_R range from 0.8% to 1.7%.^{7,25,26} Furthermore, the NACDG reports the frequency of relevant positive patch test reactions to PTBPF_R to be 1.3% in children (aged 0–18 years) and 1.1% in adults (aged ≥19 years).²⁷ Pediatric contact allergy to this resin is a significant problem. A decade ago, Bruckner et al²⁸ found that PTBPF_R was the fourth most common allergen detected; 1.2% of children in a population of 85 asymptomatic children aged 6 months to 5 years

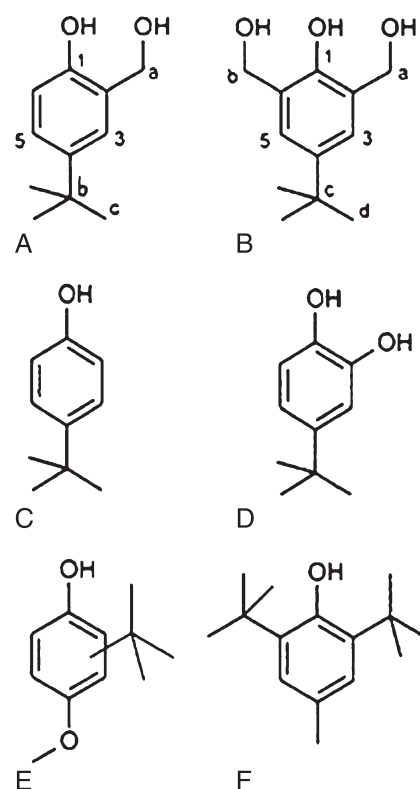


Figure 2. Chemical structures: 2-methylol *p*-*tert*-butylphenol (A); 2,6-dimethylol *p*-*tert*-butylphenol (B), *p*-*tert*-butylphenol (C), *p*-*tert*-butylcatechol (D), 2(3)-*tert*-butyl-4-hydroxyanisole (E), 3,5-di-*tert*-butyl-4-hydroxytoluene (F).

had a PPT. Moreover, in 2008, the NACDG ranked PTBPF_R as the sixteenth most reactive allergen tested.²⁷ Additionally, in a recent study of 100 patients with suspected ACD at our institution,²⁹ PTBPF_R ranked as the third most common allergen (14% of children were affected). Furthermore, we have noted an association with “foam-type” mattress covers and “memory” pillows.

Among adolescents, one relevant source of exposure to PTBPF_R is sports equipment (ie, wrist supports, shin and knee guards,^{30–32} athletic tape,³³ and swimming goggles³⁴). Athletes may be particularly susceptible to ACD because of the warm moist environment and the occlusion to which the skin is subjected. This, in addition to moisture causing the breakdown of PTBPF_R and the release of allergens, makes the inclusion of this resin in athletic gear a greater risk.³⁵

In tests for contact allergy to PTBPF_R, a concentration of 1% in petrolatum is commonly used. However, Handley et al³⁶ suggested that this resin’s inclusion in the European Standard series be questioned because of the lack of a clinically relevant source in the case of about half of the patients who had PPTs in their study. That being said, we recognize that with the ubiquitous use of PTBPF_R (beyond its association with shoes),³⁷ there may be potential sources that have been overlooked, such as toddler’s foam pillows, children’s toys, and Halloween costumes. Thus, testing of children may be necessary with presentations other than foot

TABLE 1. Products Containing *p*-*tert*-Butylphenol Formaldehyde Resin

Adhesives: glues ^{7,33} and fingernail adhesives ^{7,21}
Adhesive tapes, labels, dressings, and electrodes ³⁹
Varnishes
Leather products: shoes, ¹³ watch straps, ⁴⁰ purses, and belts
Rubber products: shoes, ¹³ neoprene wet suits, and sauna shorts ^{9,22}
Inks ⁴
Medical items: hearing aids ¹⁷ and prostheses ^{7,41}
Plywood ⁷
Sports equipment: wrist supports, shin guards, ³⁰ athletic tapes, ³³ and swimming goggles ³⁴

dermatitis. *p*-tert-Butylphenol formaldehyde resin is currently included in both the European Standard series and the NACDG standard series of allergens and serves as a screening tool for PTBPF and related allergens because formaldehyde alone is not necessarily correlated with PTBPF allergy.^{7,38}

In summary, patch test screening with PTBPF for both adults and children is important, given the ubiquitous use of this chemical.

REFERENCES

- Shackelford KE, Belsito DV. The etiology of allergic-appearing foot dermatitis: a 5-year retrospective study. *J Am Acad Dermatol* 2002;47:715–721.
- Saha M, Srinivas CR, Shenoy SD, et al. Footwear dermatitis. *Contact Dermatitis* 1993;28:260–264.
- Romaguera C, Vilaplana J. Contact dermatitis in children: 6 years experience (1992–1997). *Contact Dermatitis* 1998;39:277–280.
- Burden AD, Lever RS, Morley WN. Contact hypersensitivity induced by *p*-tert-butylphenol-formaldehyde resin in an adhesive dressing. *Contact Dermatitis* 1994;31:276–277.
- Martellotta D, Di Costanzo L, Cafiero M, et al. Contact allergy to *p*-tert-butylphenol formaldehyde resin and zinc diethyldithiocarbamate in a wet suit. *Dermatitis* 2008;19:E3–E4.
- Malten KE. Occupational eczema due to *para*-tertiary butylphenol in a shoe adhesive. *Dermatologica* 1958;117:103–109.
- Geldof BA, Roesyanto ID, van Joost T. Clinical aspects of *paratertiary*-butylphenolformaldehyde resin (PTBP-FR) allergy. *Contact Dermatitis* 1989;21:312–315.
- Zimerson E, Bruze M. Low-molecular-weight contact allergens in *ptert*-butylphenol-formaldehyde resin. *Am J Contact Dermat* 2002;13:190–197.
- Nagashima C, Tomitaka-Yagami A, Matsunaga K. Contact dermatitis due to *para*-tertiary-butylphenol-formaldehyde resin in a wetsuit. *Contact Dermatitis* 2003;49:267–268.
- p*-tert-Butylphenol Formaldehyde Resin: Contact Allergen Database. 2008. Available at: http://contactallergy.com/contact_allergy_062.htm. Accessed November 2, 2010.
- Zimerson E, Bruze M. Contact allergy to the monomers in *p*-tertbutylphenol-formaldehyde resin. *Contact Dermatitis* 2002;47:147–153.
- Zimerson E, Bruze M. Sensitizing capacity of some trimers in *p*-tert-butylphenol-formaldehyde resin. *Contact Dermatitis* 2002;47:40–46.
- Warshaw EM, Schram SE, Belsito DV, et al. Shoe allergens: retrospective analysis of cross-sectional data from the North American Contact Dermatitis Group, 2001–2004. *Dermatitis* 2007;18:191–202.
- Nardelli A, Taveirne M, Drieghe J, et al. The relation between the localization of foot dermatitis and the causative allergens in shoes: a 13-year retrospective study. *Contact Dermatitis* 2005;53:201–206.
- Rani Z, Hussain I, Haroon TS. Common allergens in shoe dermatitis: our experience in Lahore, Pakistan. *Int J Dermatol* 2003;42:605–607.
- Correia S, Brandao FM. Contact dermatitis of the feet. *Derm Beruf Umwelt* 1986;34:102–106.
- Matrolonardo M, Loconsole F, Conte A, et al. Allergic contact dermatitis due to *para*-tertiary-butylphenol-formaldehyde resin in a hearing aid. *Contact Dermatitis* 1993;28:197.
- Meding B, Ringdahl A. Allergic contact dermatitis from the earmolds of hearing aids. *Ear Hear* 1992;13:122–124.
- Avenel-Audran M, Goossens A, Zimerson E, et al. Contact dermatitis from electrocardiograph-monitoring electrodes: role of *p*-tert-butylphenol-formaldehyde resin. *Contact Dermatitis* 2003;48:108–111.
- Dahlquist I. Contact allergy to *paratertiary* butylphenol formaldehyde resin in an adhesive label. *Contact Dermatitis* 1984;10:54.
- Rycroft RJG, Wilkinson JD, Holmes R, et al. Contact sensitization to *p*-tertiary butylphenol (PTBP) resin in plastic nail adhesive. *Clin Exp Dermatol* 1980;5:441–445.
- Ozkaya E, Elinç-Aslan MS, Mirzoyeva L. Allergic contact dermatitis caused by *p*-tert-butylphenol formaldehyde resin and colophonium in neoprene thermal sauna shorts. *Contact Dermatitis* 2010;63:230–232.
- DuPont Performance Elastomers: Neoprene Polychloroprene. 2010. Available at: <http://www.dupontelastomers.com/Products/neoprene/neoprene.asp?id5wikineo>. Accessed October 28, 2010.
- Smith JK. The ten-year invention: Neoprene and DuPont research, 1930–1939. *Technol Culture* 1985;26:34–55.
- Bruze M, Fregert S, Zimerson E. Contact allergy to phenolformaldehyde resins. *Contact Dermatitis* 1985;12:81–86.
- Fregert S. Contact allergy to phenolplastics. *Contact Dermatitis* 1981;7:170.
- Zug KA, McGinley-Smith D, Warshaw EM, et al. Contact allergy in children referred for patch testing. North American Contact Dermatitis Group data, 2001–2004. *Arch Dermatol* 2008;144:1329–1336.
- Bruckner AL, Weston WL, Morelli JG. Does sensitization to contact allergens begin in infancy? *Pediatrics* 2000;105:e3.
- Jacob SE, Herro EM, Matiz C, et al. Frequency of allergens in pediatric patients with atopic dermatitis.
- Hsu J, Jacob SE. The other side of athletic safety gear in adolescents: the role of *p*-tert-butylphenol-formaldehyde-resin in allergic contact dermatitis. *J Dermatol Nurs* 2009;1:198–200.
- Vincenzi C, Guerra I, Peluso AM, et al. Allergic contact dermatitis due to phenol-formaldehyde resin in a knee-guard. *Contact Dermatitis* 1992;27:54.
- Sommer S, Wilkinson SM, Dodman B. Contact dermatitis due to urea-formaldehyde resin in shin-pads. *Contact Dermatitis* 1999;40:159–160.
- Shono M, Ezoe K, Kaniwa M, et al. Allergic contact dermatitis from *para*-tertiary-butylphenol formaldehyde resin (PTBP-FR) in athletic tape and leather adhesive. *Contact Dermatitis* 1991;24:281–288.
- Azurdia RM, King CM. Allergic contact dermatitis due to phenolformaldehyde resin and benzoyl peroxide in swimming goggles. *Contact Dermatitis* 1998;38:234–235.
- Rietschel RL, Fowler JF, eds. *Fisher's Contact Dermatitis*. Philadelphia, PA: Lippincott Williams & Wilkins; 2001.
- Handley J, Todd D, Bingham A, et al. Allergic contact dermatitis from *para*-tertiary-butylphenol-formaldehyde resin (PTBP-F-R) in Northern Ireland. *Contact Dermatitis* 1993;29:144–146.
- Worm M, Aberer W, Agathos M, et al. Patch testing in children—recommendations of the German Contact Dermatitis Research Group (DKG). *J Dtsch Dermatol Ges* 2007;05:107–109.
- Foussereau J, Cavlier C, Seling D. Occupational eczema from *paratertiary*-butylphenolformaldehyde resins: a review of the sensitizing resins. *Contact Dermatitis* 1976;2:254–258.
- Moran M, Martin-Pascual A. Contact dermatitis to *para*-tertiarybutylphenol formaldehyde. *Contact Dermatitis* 1978;4:372–373.
- Mobackern H, Hersle K. Allergic contact dermatitis caused by *paratertiary* butylphenol-formaldehyde resin in watch straps. *Contact Dermatitis* 1976;2:59.
- Sood A, Taylor JS, Billock JN. Contact dermatitis to a limb prosthesis. *Am J Contact Dermat* 2003;14:169–171.