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Abstract

Boats are made of various materials such as reinforced plastic (plastic composites), metal (aluminum and steel), wood, or plywood. Construction of boats includes several phases from the manufacturing of a mold for the hull to finishing with various materials and chemicals. Therefore boatbuilding is an industry with exposure to a very large variety of chemicals potentially harmful to the skin.

The most significant skin sensitizers in the boatbuilding industry are various thermosetting plastics (epoxy, polyester, polyurethane, acrylic resins, or their additives).

Construction of wooden boats and cabins includes carpentry tasks.

The choice of allergens must be based on the individual exposure, i.e., products used at work must be studied. Patch testing patient's own materials is recommendable as commercial allergen preparations are often lacking.

Keywords

Glass fiber · Carbon fiber · Epoxy resins · Isocyanates · Polyester resins · Lacquers · Varnishes

1 Introduction

Boats are made of various materials such as reinforced plastic (plastic composites), metal (aluminum and steel), wood, or plywood. Construction of boats includes several phases from the

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manufacture of a mold for the hull to finishing with various coatings or upholsteries (padding, carpeting). Therefore boatbuilding is an industry with a very large variety of chemical exposures potentially harmful to skin.

2 Work tasks and exposure

Plastic boats are usually manufactured from polyester resin, epoxy resin, or epoxy vinyl ester resins (epoxy acrylate resins) by lamination methods. Glass fiber or carbon fiber is used as reinforcement. Molds are usually made of reinforced polyester resin. Polyester resin or epoxy putties are used to fill depressions in the molds and the hull. Fiber reinforcements impregnated with resin (prepregs) can be used instead of separate fibers and resins. The hull cavities may be filled with large volumes of newly mixed polyurethane foam to increase floating.

Finishing the cured hull includes sawing, sanding, and cutting. Resultant dust may still contain sensitizing monomers or oligomers. Plastic hulls are coated with several layers of primer and paint (gel coats, base coats, top coats, and antifouling paints) to form the desired surface and to enhance durability. The coatings are based on polyesters, polyurethanes, epoxies, or acrylates, while the antifouling paints may contain, e.g., colophony and biocides in high concentrations (www.hempel.com, www.yachtpaint.international.en). Epoxy, acrylic, or polyurethane glues are used for assembly work and interior parts, and polyurethane foam is added as filling and insulator. Finishing of boats includes various coatings, paints, and glues (e.g., acrylates, epoxies, polyurethanes, phenol formaldehyde resins).

Construction of wooden boats and cabins includes carpentry tasks (see ► [Chap. 134, “Carpenters”](#)). Wooden boat hulls are made of various wood species such as pine, spruce, and oak; exotic wood species such as teak or obeche may be used for fine surfaces, decorations, and smaller parts. Their finishing, similar to plastic boats, requires waxes, fillers, varnishes, and paints based on both natural and synthetic

materials. Manufacture of metal boats may require welding (see ► [Chap. 200, “Welding”](#)), tooling (see ► [Chap. 66, “Cutting Fluids”](#)), coating, and assembly processes.

3 Allergens

The most significant skin sensitizers in the boatbuilding industry are various thermosetting plastics (epoxy, polyester, polyurethane, acrylic resins, or their additives; see the specific chapters and [Table 1](#)). Boatbuilders are a small occupational group, so case reports are quite rare and they are difficult to find in reports of larger patient series (Aalto-Korte et al. [2018](#)). There are reports of contact allergy of boatbuilders at least from polyester resin (Liden et al. [1984](#)), diphenylmethane diisocyanate (MDI) (Aalto-Korte et al. [2012](#)), bisphenol A and bisphenol F epoxy resin (Aalto-Korte et al. [2014a](#)), diethylene triamine (DETA) (Aalto-Korte et al. [2014b](#)), 1,6-hexanediol diglycidylether (HDDGE) (Aalto-Korte et al. [2015](#)), 2-tert-butylamino-4-cyclopropylamino-6-methylthio-1,3,5-triazine in an antifouling paint (Andersson [1997](#)), cobalt naphthenate in an accelerator for polyester and vinyl ester resins (Tarvainen et al. [1993](#)), and phenol formaldehyde resin in a glue (Tarvainen et al. [1993](#)). Practically all plastic-related allergens are possible sources of sensitization in boatbuilding. Gums and resins of, e.g., pine species and exotic woods, need to be considered as potential contact allergens in this work, too.

The choice of allergens must be based on the individual exposure, i.e., products used at work must be studied. Patch testing patient’s own materials is recommendable as commercial allergen preparations are often lacking. Of course the usual occupational allergens used in any risk occupation must be remembered in boatbuilders also. They include thiurams and other rubber chemicals, chrome in leather gloves, other components of protective gloves, as well as preservatives, fragrances, and other components of hand cleansers and hand creams.

Table 1 Contact allergens, test concentration, and vehicle

Allergen	Test concentration and vehicle	Application/use
Epoxy resin (diglycidylether of bisphenol A)	1% pet.	Lamination resins, glues, paints, screeds, putties
Epoxy resin (diglycidylether of bisphenol F)	0.25% pet.	Lamination resins, putties, glues, paints
Other epoxy compounds, e.g., diethylene triamine (DETA), 1,6-hexanediol diglycidylether (HDDGE)		Various epoxy products and their hardeners
Diphenylmethane diisocyanate (MDI)	1% pet.	MDI in hardeners for polyurethane foams and other products
Polymeric MDI	2% pet.	
4,4'-Diaminodiphenylmethane (MDA) (as an indicator of MDI allergy)	0.5% pet.	
Other isocyanates possible (e.g., isophorone diisocyanate, hexamethylene diisocyanate, toluene diisocyanate)		
Cobalt chloride	1% pet.	Polyester resin accelerator
Phenol formaldehyde resin (resol; PFR)	1% pet.	Glues, plywood, chipboard
p-tert-butylcatechol (possible)	0.5% pet.	Polyester resin inhibitor
Other allergens in plastic and glue series (possible)		
Formaldehyde	2% aq.	Formaldehyde resins in glues, plywood, and chipboard
Methacrylates, acrylates, and epoxy acrylates (vinyl esters) according to exposure		Lamination resins, glues, lacquers, varnishes, resins
Polyester cement putty, resin part	5% pet.	
Polyester cement putty, hardener	1% pet.	
Cured polyester putty, e.g., putty dust	10–20% pet.	
Polyester lamination resin, resin part	5% pet.	
Polyester lamination resin, hardener	1% pet.	
Wood dusts, e.g., teak	10% pet.	
Colophony	20% pet.	Varnishes and glues; pinewood, antifouling paints

4 Irritants

Table 2 lists some common contact irritants in boat building industry.

Table 2 Contact irritants in boat building

Abrasives (abrasive wheels, sandpaper)
Glass fibers
Carbon fibers
Lacquers and varnishes
Paints
Plastic dust
Wood dust
Resins and their hardeners

Adhesives

Soaps and detergents

Styrene and other solvents

5 Specific Aspects

In order to prevent skin diseases in boatbuilding industry, special care should be paid on the chemical safety. This includes, e.g., keeping the chemical inventory and safety data sheets up-to-date, assessment of chemicals risks in different

work tasks, safe and tidy working methods, suitable protective clothing, and guidance of the workers. If problems arise, detailed chemical information are needed both for choosing the skin tests to represent the patient's exposure and for showing the relevance of possible contact allergies.

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