SOL-GEL TREATMENTS FOR ENHANCING FLAME RETARDANCY OF COTTON

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Recently, fatal accidents caused by the burning of fabrics have remarkably motivated both the academic and the industrial research to study and produce smart textiles with flame retardant properties. The combustion behavior of fabrics is very complex and depends on their nature and characteristics. In particular, although cotton is known to be the most common natural fiber used for several applications (wearing apparel, upholstery, furniture, mattresses, bed-lines...), it is also a highly combustible fiber, as well as its blends with polyester. Several flame retardant additives, such as halogen derivatives or phosphorus-based compounds have been used, notwithstanding their possible adverse effects on the environment. For this reason, among the alternative procedures, the use of the sol-gel technique is becoming a relatively novel process in the textile field for conferring flame retardancy and thermal stability. The treatment of fabric surfaces by means of a sol–gel process from a solution has been described as an encouraging approach, since it can lead to the formation of hybrid organic–inorganic coatings at or near room temperature.

Sol-gel processes are based on two steps involving hydrolysis and condensation reactions starting from (semi)metal alkoxides, like tetraethoxysilane, tetramethoxysilane, titanium tetraisopropoxide.

In this context, a detailed investigation on the possibility of obtaining the formation of silica architectures (particles, coatings) on cotton fabrics has been carried out by using the sol-gel technique. The effect of different process parameters such as silica precursor type, silica precursor:water molar ratio and drying conditions (namely, temperature and time) has been thoroughly investigated, aiming to optimize the sol-gel procedure applied to cotton textiles. Cone calorimetry tests have been exploited in order to assess the fire resistance of the treated fabrics; in addition, the thermal stability of the obtained products has been evaluated by thermogravimetric

analyses, performed both in nitrogen and air. The coating durability to different washing programs has been studied as well [1, 2].
Furthermore, the possibility to utilize joint or synergistic effects between the obtained silica phases and commercial phosphorus-based flame retardants has been explored [3]. Very recently, the role of several silica precursors, which differ as far as their structure is concerned (i.e. number and type of hydrolysable groups, presence of aromatic rings), has also been investigated [4].
Alternatively to silica-based coatings (derived from tetraethylortho-silicate), it has been demonstrated that interesting oxidic phases can be deposited on cotton fabrics starting from other alkoxides (tetraethylortho-titanate or -zirconate and aluminium isopropylate). Titania, zirconia and alumina turned out to significantly enhance the flame retardancy of cotton fabrics, although their efficiency was lower than silica [5]. In addition, the effect of such oxidic phases as efficient smoke suppressants has been studied [6].
Finally, the effect of a hybrid organic-inorganic coating obtained through a dual-cure process (i.e. a photopolymerization followed by a thermal treatment for promoting sol-gel reactions) on the thermal stability, fire resistance and combustion behavior of cotton fabrics has been assessed [7].

1. Alongi J., Ciobanu M., Carosio F., Tata J., Malucelli G. J. Appl. Polym. Sci. 119:1961-1969, 2011.
2. Alongi J., Ciobanu M., Malucelli G. Cellulose 18:167-177, 2011.
3. Alongi J., Ciobanu M., Malucelli G. Carbohydr. Polym. 85:599-608, 2011.
4. Alongi J., Ciobanu M., Malucelli G. Carbohydr. Polym. 87:627-635, 2012.
5. Alongi J., Ciobanu M., Malucelli G. Carbohydr. Polym. 87:2093-2099, 2012.
6. Alongi J., Malucelli G. Cotton fabrics treated with novel oxidic phases acting as effective smoke suppressants, Carbohydr. Polym., In press.
7. Alongi J., Ciobanu M., Malucelli G. Cellulose 18:1335-1348, 2011.