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NOTE

Effect of Deposited Sodium Stannite on the Flame Retardancy Imparted to Cotton Fabric

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The effect of sodium stannite on the flammability of cotton fabric (Woven, 178 g/m^2) has been of interest in this investigation. The aforementioned salt was synthesized by using suitable concentrations of NH_4OH, NaOH and $SnCl_2$ solutions. The optimum add-on values to impart flame-retardancy were about 5.9–6.5 g anhydrous sodium stannite per 100 g cotton fabric. The results obtained are in favour of the thermal theory. However, after the ignited specimens ceased to flame, the presence of glow was observed. Hence the condensed phase retardation cannot be justified.

Key Words: Flammability, Flame-Retardancy, Char length, Thermal theory, Condensed phase retardation.

The need for reduced flammability in several consumer products such as fibres, plastics etc. has gained great importance these days, *e.g.*, the necessity for diminished flammability in various textiles has been increased by governmental legislations in many countries. Textiles are referred to as flame-retardant which burn with difficulty and which cease to burn on the removal of the source of flame[1-3].

The whole value of flame-retardants sold in Europe in 2003 are halogen-based organics 26%, inorganic compounds including $Mg(OH)_2$, $ZnSnO_3$, Sb_2O_3, borates 36%[4-6] and phosphorus-based chemicals 38%.

Amongst the flame-retardants, the application of tin based compounds such as $ZnSnO_3$ in PVC, thermoplastics polyester resins and certain resin-based gloss paints is mentionable[5].

The purpose of this study is to investigate the effect of sodium stannite on the flame-retardancy imparted into cotton fabric. It is noticeable that in presence of caustic alkalies, the Sn^{2+} solution gives a white precipitate of $Sn(OH)_2$:

$$Sn^{2+} + 2OH^- \longrightarrow Sn(OH)_2 \quad \text{or} \quad (H_2SnO_2)$$

The precipitate is soluble in both acids and strong alkalis. When dissolved in caustic alkalis such as KOH and NaOH, it forms stannites, SnO_2^{2-} ions[7]:

$$H_2SnO_2 + 2OH^- \longrightarrow SnO_2^{2-} + 2H_2O$$

Therefore the soluble salt, *i.e.*, Na_2SnO_2, has been selected, synthesized and applied into the cotton fabric and investigated for its impartation of flame-retardancy.

All specimens were a woven construction, weighing 178 g/m^2, unfinished 100% cotton, laundered and dried. The fabrics were 22 by 8 cm strips cut along the waft direction and pre-washed in hot distilled water. Afterwards, the specimens were dried horizontally at 110°C for 30 min in an oven, cooled in a desiccator and weighed with analytical precision.

Bath Treatment: With the exception of the first bunch, all other specimens were impregnated with suitable concentrations of sodium stannite (at 20°C) prepared as follows:

200 mL of 2 M NaOH solution was added to 200 mL of 1 M $SnCl_2$ solution. The precipitate $Sn(OH)_2$ was filtered and rinsed with sufficient distilled water in order to remove impurities. Then $Sn(OH)_2$ was dissolved in 200 mL of 2 M NaOH solution. Afterwards, different solutions of Na_2SnO_2 with concentrations of 0.20, 0.22, 0.25 and 0.35 M were prepared independently. Then, each bunch of fabrics was impregnated separately. Afterwards, the specimens were squeeze-rolled and dried horizontally in an oven at 110°C for 30 min, then cooled in a desiccator and weighed in an analytical balance.

Flammability test: The vertical test method similar to the procedure described in DOC FF 3–71[8] was applied. According to the aforementioned test an aluminum frame with the following specifications has been applied: Two strips of 3 mm aluminum double-sheet, 22.5 by 1.5 cm, are cut, perforated and welded at right angles to a shorter 9 cm strip. The conditions of the fabrics and environment were average temperature ranging between 20 and 22°C, and the average relative humidity (RH) ranged between 65 and 67%, *i.e.*, the specimens were conditioned overnight before the fulfillment of the vertical tests.

The fabrics were pinned tightly to the frame and held vertically in a retort stand by clamps with the lower edge 1.9 cm above the top of a bunsen burner with a 3 cm yellow flame and an ignition time of 3 s. This performance was conducted in order to avoid the harsh ignition circumstances. Then the burning time in the nearest 0.1 s and the length of char was determined to the nearest cm.

Repeatability of burning time was ±5% for untreated fabric. This repeatability was much lower for salt treated fabrics. In fact, the pad squeeze process gave a certain amount of variability.

The experimental results are listed in Table-1. Vertical flame test was carefully conducted to determine the add-on values corresponding to flame-resistance. Fabrics were considered flame-retarded when the char length of less than 2.0 cm was obtained. It can be seen that a range of 5.9–6.5% sodium stannite is quite sufficient to impart flame-retardancy to cotton fabric while the inadequate quantities of the flame-retardant *i.e.*, 3.3–5% of sodium stannite added into the fabrics decreased the burning times and increased the burning rates. These results are in favour of the statements suggested by Reeves and Hammons[9].

In general, the use of tin-based chemicals as flame-retardants have a great potential in future as most of them are non-toxic, apparently producing none of the hazardous side-effects of the widely used phosphorus-based materials[5].

TABLE-1
THE EFFECT OF DEPOSITED SODIUM STANNITE ON THE FLAME-RETARDANCY IMPARTED TO COTTON FABRIC (WOVEN 178 g/m^2)

Bunch No*	Treating solution molarity	Per cent (add-on) drying at 110°C and weighing	Burning time in seconds	State of the fabric	Char length (cm)	Burning rate (cm/s)
1	Untreated fabric	—	37.5	CB	—	0.59
2	0.20	3.3	26.5	CB	—	0.83
3	0.22	5.1	12.0	PB	20.5	1.70
4	0.25	5.9	—	FR	0.2	—
5†	0.35	6.5	—	FR	0.2	—

* Average of 5 tests for each bunch. CB = Completely burned; PB = partly burned; FR = flame-retarded.

† Confirmatory tests using excessive quantities of the flame-retardant.

Recently the author has tested selected inorganic compounds to investigate their capability to be used as flame-retarders on cotton fabric[6, 10, 11], hereby that sodium stannite is one of the best inorganic flame-retarders imparting excellent flame-resistance to cotton fabric. However, the phenomenon of the so-called smoldering or glowing has been observed. Hence, the condensed phase retardation[12] does not seem to play any role in the above-mentioned action, *i.e.*, the applied flame-retarder could not promote the formation of solid char, in case the polymer has been subjected to thermal degradation.

Instead of this, the flame-retardancy of the sodium stannite seems to be in favour of the thermal theory[2, 13]. According to this theory, the heat of combustion may be dissipated away from the inflamed fabric at a comparable rate to that at which it is being supplied. Therefore, the volatile products so evolved in the flame and reacting with oxygen cannot produce enough heat to continue the thermal decomposition of the polymer.

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