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*NOTE*

# Effect of Deposited Calcium hydrogen phosphate dihydrate on the Flame-Retardancy Imparted to Cotton Fabric

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The influence of calcium hydrogen phosphate dihydrate on the flammability of cotton fabric (serge construction, 220 $g/m^2$) is investigated. The samples were impregnated with suitable concentrations of aqueous solutions of calcium hydrogen phosphate dihydrate by means of squeeze rolls and dried in an oven at 110°C for 30 min. Then the samples were cooled in a desiccator, weighed and kept under ordinary conditions before the accomplishment of the vertical flame test. The optimum add-on value to impart flame and glow retardancy was about 23.0 g of calcium hydrogen phosphate dihydrate per 100 g fabric. The results obtained comply with chemical theory, coating theory and condensed phase retardation theory.

**Key Words: Calcium hydrogen phosphate dihydrate, Flame-retardancy, Cotton fabric.**

The inorganic compounds most widely used as flame-retardants are halogenated compounds and phosphorus components[1]. Depending on the nature of the additives, they can act chemically or physically in the solid, liquid or gaseous phase. For example, phosphorus compounds reduce the formation of flammable carbon containing gases by increasing the conversion of polymeric materials to a char residue during pyrolysis[1]. Apart from flame-retardancy, many borates and phosphates have been also found to be effective in suppressing the afterglow[2].

The purpose of this study is to investigate the influence of calcium hydrogen phosphate dihydrate on the flammability of cotton fabric.

All fabrics were of "serge" construction, weighing 220 $g/m^2$, unfinished 100% cotton, laundered and dried. They were 22 × 8 cm strips cut along the warp direction and pre-washed in hot distilled water.

## Bath treatment

With the exception of the first bunch, all other samples were impregnated with suitable concentrations of calcium hydrogen phosphate dihydrate at 20°C. Afterwards, the fabrics were squeeze-rolled, dried horizontally in an oven at 110°C for 30 min followed by cooling in a desiccator and then reweighed so that the suitable add-on presented into the specimens was obtained. The treated fabrics were kept overnight under ordinary conditions before the fulfilment of the flammability test, so that the humidity regain obtained during this period.

**Flammability test**

A vertical flammability test method similar to the procedure in DOC[3] was used. The aforementioned tester is a an aluminum double-sheet, 22.5 × 1.5 cm, cut, perforated and welded at right angess to a shorter 9 cm strip. The samples 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 3 cm yellow flame of a bunsen burner so that the harsh ignition circumstance is avoided. This producer and other details have been described previously[2,4]. Repeatability of burning time was ±5% for untreated specimens. This repeatability for salt treated fabrics was much lower. In fact, the pad squeeze process is known to give a certain amount of variability. After an ignition time of 3 s at the bottom edge, the total burning time was measured to the nearest centimetre. It is mentionable that the ignition time was subtracted from the total combustion duration and then the rest was reported as the burning time. The flammability test was conducted in a put-out fume-cup board prior the fulfilment of the combustion. However, the exhaust ventilator had been turned on for about 5 min after each burning so that the consumed toxic gases were conducted away from the environment and fresh air could enter around the experimental apparatus.

It can be inferred from the results (Table-1) that about 23.0% of calcium hydrogen phosphate dihydrate is efficient to impart flame-retardancy to the fabric. The burning characteristics of the treated samples indicate suitable effectiveness in suppressing the after-glow *i.e.*, the flameless combustion was quenched[5]. The plausible mechanism of such flame and glow retardancy can be justified by the chemical theory[6,7].

TABLE-1
EFFECT OF DEPOSITED CALCIUM HYDROGEN PHOSPHATE DIHYDRATE ON THE FLAME-RETARDANCY IMPARTED TO COTTON FABRIC
(serge construction weighing 220 g/m$^2$)

| Bunch No.* | Treating solution $CaHPO_4 \cdot 2H_2O$ molarity | Per cent (add-on) drying at 110°C and weighing | Burning time (s) | State of the fabric† | Burning rate (cm/s) | Char length (cm) |
|---|---|---|---|---|---|---|
| 1. | Untreated | — | 35.2 | CB | 0.62 | — |
| 2. | 1.00 | 13.0 | 44.9 | CB | 0.49 | — |
| 3. | 1.25 | 23.0 | 1.7 | FR | — | 1.5 |
| 4.‡ | 1.50 | 36.5 | 0.3 | FR | — | 0.1 |

*Average of 5 tests for each bunch.
†CB = completely burnt and FR = flame-retarded.
‡Confirmatory tests using excessive amounts of the additive.

Calcium hydrogen phosphate dihydrate as a phosphorous containing compound deposited into cotton fabric showed a tendency towards flame and glow retardancy. It is noticeable that as a phosphorus containing flame and glow retardant it can be converted to phosphoric acid by thermal degradation, which expels water from the pyrolyzing cellulosic substrate, converting it to char[8]. The generation of char observed in the experiments justifies this suggestion. The optimum add-on value to impart flame-retardancy was about 23 g of this salt per 100 g cotton fabric. It can be recommended to apply this additive in conjunction with other flame-retardants to achieve a better performance on the flame-retardancy, *i.e.*, using the synergistic influence may be beneficial to improve the above-mentioned effect.

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