New rodent repellent and UV resistant nylon tapes for aircraft arrester net

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A new rodent repellent and UV resistant nylon tape for the fabrication of fighter aircraft arrester net has been developed. Oleoresin, a sensory irritant from natural sources has been used along with black carbon and butyl recinoleate. These tapes have been found to be effective against rodents under laboratory conditions.

A multi-element net made of nylon tapes is used to stop an aircraft in the aircraft arrester barrier system, which is used by the Air Force to block the forward momentum of the aircraft from overshooting the runway during its emergency landing or reject take-off. Since the nylon nets remain in open ground all the time, they are damaged by rodents in addition to their undergoing a decline in strength due to UV radiation from sun rays. This leads to decrease in the service time of the nylon nets. Because of the increasing concern over the deleterious effect of UV radiation as well the damaging action of rodent on aircraft arrester net in the field conditions, there is a need for a suitable product/material, which can provide the protection, to the net both from UV radiation and rodent attack. Several photostabilizers such as 2-hydroxybenzophenone derivatives and phenolic antioxidants, are known to provide protection from UV radiation, but have limited applications under extreme environmental conditions. In addition, rodents/wild animals also pose a great threat to the net, when either kept in the storage or erected in air bases. Use of rodenticides, repellents and trapping, are the main approaches used on a large scale, to tackle, rodent problems. Again, in the field conditions, all the above methods provide only short-term control measures, and have limited application. Naphthalene/sulphur mixture powder is also known to be used for rodent repellent, but because of high volatility of naphthalene, it cannot be used under field conditions. No report is available in the literature for simultaneous protection of nylon tapes both from UV radiation and rodent attack. The present study has, therefore, been designed to develop a new UV resistant and rodent repellent tapes for aircraft arrester, by impregnating the tapes with carbon black along with a naturally occurring sensory irritant, without affecting its original mechanical characteristics.

Experimental Procedure

Chemicals/Materials

Butyral resin (composition: 20% polyvinyl alcohol, 78% polyvinyl acetal and 2% polyvinyl acetate), butyl recinoleate, carbon black (800 mesh size), rectified spirit were obtained commercially. Oleoresin containing 30% capsaicinoids was isolated from Nagahari chilli in our laboratory and used for impregnation. Nylon tapes (26 mm width, 45 g/m weight), purchased from M/s Tex Mill spares Pvt. Ltd, Jaipur were used in this study.

Impregnation of Oleoresin and Carbon Black in Nylon Tapes

100 g of Butyral resin was added slowly to 500 mL of rectified spirit and the mixture was stirred continuously to turn it into a homogeneous solution. To this, 50 g carbon black, 100 g butyl recinoleate and 15g (1.5% w/v) oleoresin, were added. This was diluted further with 500 mL of rectified spirit. The whole mixture was transferred into a ball jar machine, and mixed for 48 h.

The viscosity of the resulting solution was adjusted to 50 s (at 30°C, Flow cup method, IS 3944 B4) by the addition of required rectified spirit, and the whole solution was taken in a reservoir. The nylon tapes were impregnated by passing through this solution. Excess solution was removed by squeezing the tapes

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in between two adjustable rollers. The tapes were dried at 45°C for 45 min, and then cured at 140-150°C for 5 min in a chamber. The squeezing of the solution was maintained so that the increase in weight of the cured tape did not exceed the original mass by 5 to 10%.

Similarly, nylon tapes were also impregnated with solutions, prepared by using 9 g (0.9% w/v) naphthalene powder and 36 g (3.6% w/v) sulphur powder mixture by the abovementioned method. Control tapes were also prepared by following the above method.

**Accelerated ageing test**

This was carried out in a accelerated weathering unit consisting of: carbon arc lamp, surrounded by filters; rotating rack to hold the sample tapes; water spray with pressure control and temperature controller. Five samples of control and treated tapes were placed in the rack in such a way that one impregnated alternates with that of control. The samples were kept 2.5 cm apart from each other. The samples were exposed to carbon arc light for a total of 100 hours and then conditioned to standard atmosphere conditions for 24 h. Later, the breaking strength of the tapes were tested (Table 1).

**Nylon tapes evaluation against rodents**

Six wild type rats (trapped from field) were released in each wire mesh rodent cage (60x30x25cm) and they were allowed to acclimatize under laboratory conditions for three days. They were fed with normal feed and water daily. Oleoresin and sulphur/naphthalene impregnated nylon tape strips as well as control strips (12.5 cm length, 4 nos each) were suspended vertically in different wire mesh rodent cages. The rodent repellent property of the impregnated/control tapes was assessed by everyday monitoring of the tapes for any visual damage.

**Results and Discussion**

The aircraft arrester system is made up of a multi-element net of 58 m length and 5 m in width, comprising 90 horizontal and 570 vertical strips of the nylon tapes kept vertically by mechanical means during emergency. These tapes are open to field rats attack in the airfield conditions which leads to damage and loss. In such conditions, repellency effects are normally created by physical stimuli described in the literature such as UV light and high-intensity sounds, which require continuous maintenance.

It is well known that rodents are particularly sensitive to odours and tastes, and it has been shown that a number of chemical substances possess repellent properties. However, apart from repellency, there are rigorous requirements for incorporating the repellent substance which include stability, no objectionable odour, absence of toxic properties and more important, no effect on the original quality of material (e.g., nylon tape). Oleoresin *Capsicum* is a natural product isolated from chilies. It contains predominantly capsaicin and dihydrocapsaicin along with its other analogs. The mixture is called capsaiacinoids, and is responsible for its irritant properties. Oleoresin is a less toxic, more potential, environment-friendly sensory irritant.

The results of evaluation of various physical parameters and the rodent repellent property of the control, oleoresin- and naphthalene/sulphur mixture impregnated nylon tapes are given in Table 1. Accelerated ageing tests for UV resistance were performed for both control as well as treated tapes for 100 hours. It has been observed that physical

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control tape</th>
<th>Sulphur/naphthalene treated tape</th>
<th>Oleoresin capsicum treated tape</th>
<th>Optimum requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m)</td>
<td>47.3 ± 0.5</td>
<td>47.1 ± 0.5</td>
<td>47.2 ± 0.5</td>
<td>45-50</td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>2.37 ± 0.05</td>
<td>2.34 ± 0.04</td>
<td>2.33 ± 0.04</td>
<td>2.2 - 3.0</td>
</tr>
<tr>
<td>Breaking strength before accelerated aging test (kg)</td>
<td>2240 ± 40</td>
<td>2185 ± 15</td>
<td>2305 ± 35</td>
<td>2040 (min)</td>
</tr>
<tr>
<td>Breaking strength after accelerated aging test (kg)</td>
<td>2215 ± 15</td>
<td>2190 ± 13</td>
<td>2235 ± 35</td>
<td>1935 (min)</td>
</tr>
<tr>
<td>Extractable material (%)</td>
<td>6.48 ± 0.5</td>
<td>6.8 ± 0.5</td>
<td>6.7 ± 0.5</td>
<td>3.0 - 8.5</td>
</tr>
<tr>
<td>Rodent repellency (days)</td>
<td>2 to 5</td>
<td>59</td>
<td>&gt;180</td>
<td></td>
</tr>
</tbody>
</table>

*Exposure to 6 field rats in a cage
properties such as weight, thickness, breaking strength and extractable material did not change after impregnation. This clearly indicates that impregnated tapes can provide stability against solar UV radiation for a very long time. In the laboratory experiments, it was also observed that the control tapes were found to be damaged by rodents in 2 to 5 days, whereas the oleoresin impregnated tapes were intact even after 180 days. In case of naphthalene/sulphur impregnated tape, the protection was found to be only for 84 days. Animal experiments have been conducted in the most stringent conditions in the laboratory where the tapes were with animals all the time (24 h a day) and in contact for 180 days continuously. The rodents have not damaged the tapes even in these conditions. From this study it can be concluded that protection index in the field condition will be very high essentially because rodents/wild animals have free access in the field and may come in contact with the net occasionally. Moreover, the incorporation of oleoresin in the tape has not affected its original properties also, and has provided protection against rodents attack. Further, the stability of oleoresin after impregnation on the tape was confirmed by extraction of the treated tape with methanol, and analysed using C18 reversed phase high performance liquid chromatography (HPLC)\(^{(18)}\). Thus, the development of a new rodent repellent and UV resistant nylon tape is achieved using easily available oleoresin and carbon black.

In the present study, a new rodent repellent and UV resistant tapes for fighter aircraft arrester net has been developed. Data obtained in this study have demonstrated that treated nylon tapes are very effective against rodents and chemical treatment has increased the life of the net.

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**References**