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Flammability test in specimens of OXIDIZED PAN fibers with automotive thermoacoustic coating blanket

Ensaio de inflamabilidade em PAN-OXIDADA com manta de revestimento termoacústica automotiva

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ABSTRACT

OXIDIZED PAN fibers are a commercial material produced from the oxidation of polyacrylonitrile fibers that has flameproof characteristic and can be applied as a thermal barrier. This work aims to evaluate the effectiveness of OXIDIZED PAN fibers, produced from textile material, as flameproof barrier in automotive vehicles. For this purpose, the specimens were produced using material similar to the inner lining of vehicles protected by a blanket of OXIDIZED PAN fibers as a thermal barrier. The flammability test was performed according to UL-94 and CONTRAN standards. The main result was a significant reduction in the flammability of the automotive material when it had two faces covered with OXIDIZED PAN fiber felt. The results indicate the possibility of using this material, national and low cost, in the automotive industry as a security item.

Keywords: flammability test; flameproof, polyacrylonitrile fibers, OXIDIZED PAN.

RESUMO

A PAN-OXIDADA é um material comercial produzido a partir da oxidação de fibras de poliacrilonitrila que possui característica antichama podendo ser aplicada como barreira térmica. Este trabalho visa avaliar a eficácia do feltro de fibra PAN-OXIDADA, produzidas a partir de PAN têxtil, como barreira antichama em veículos automotivos. Para isso, foram produzidos corpos de prova utilizando-se material semelhante à forração interna de veículos protegidos por uma camada de feltro de PAN-OXIDADA como barreira térmica. Os testes de inflamabilidade foram realizados de acordo com as normas UL-94 e CONTRAN. Como principal resultado observou-se uma significativa redução da capacidade de inflamabilidade do material automotivo quando este possuía duas faces recobertas com PAN OXIDADA. Os resultados indicam a possibilidade do uso deste material, nacional e de baixo custo, na indústria automotiva como um item de segurança.

Palavras-chave: teste de inflamabilidade; antichama, fibras de poliacrilonitrila, PAN-OXIDADA.

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INTRODUCTION

Nowadays it is very common to see in the news that cars are destroyed by burning every day, whether they are due to electrical failure or flammable fluids leakage. According to the fire department of the São Paulo State, more than 200 calls are answered every day[1].

In order to avoid/minimizing damages or increasing the survival chances of the passengers, automotive manufacturers need complying to the regulatory standards containing the guidelines of the national traffic policy, which in Brazil is represented by the National Traffic Council (CONTRAN).

According to CONTRAN[2], in one of its resolutions (Nº 675/1986), they quoted about the flame propagation in the inner lining of vehicles: "...they must present a maximum flame propagation velocity of 250 mm/min". The organizations of the most developed countries, where control is more rigid, has a burning limit of 80 mm/min[3].

Currently, in the vehicles, the inner liner is composed of mixed textile fibers bounded by polypropylene thermoplastic yarns, on this layer it is applied the carpets which are composed by polyester fiber needled (polyethylene terephthalate) with resin base (vinyl resin)[4].

One of the possibilities for the increasing safety in vehicles is the materials usage that already has thermal and chemical resistance, and one known as PANOX® is an example of this material. This has proved to be an interesting material to be used as a thermal barrier and flameproof. On the other hand, it is an expensive material, because it is manufactured with carbon fiber precursor, which makes it impossible to use in a massive way.

The OXIDIZED PAN fibers differ from PANOX® because it is produced with PAN fiber textile, that is an inexpensive material and, consequently, with a wide range of use. Due to its structurally and chemically inert characteristics, in other words, it does not burn or melt, the OXIDIZED PAN fibers also has excellent fire and heat resistance[5].

In last years, some researchers have been studied many applications for a non-woven blanket made of OXIDIZED PAN as flameproof barriers. From these studies, some patents are been published emphasizing the usage of OXIDIZED PAN fibers for protecting automobile exteriors and interiors[6,7], industrial equipment[8], used to make a flameproof composite for mattresses and mattress foundations[9] and also matched with another materials, as glass and aramid fibers, to created a light weight fire barrier structure for aircraft[10].

In order to obtain better flammability results in materials for automotive coatings requested by CONTRAN[2] and to approximate regulated values in international organizations, this work suggest a flammability study of new set of material to act as flameproof material in inner lining of vehicles. For this propose, a non woven fabric made of OXIDIZED PAN fibers, here called as OXIDIZED PAN blanket, was chosen to coat a thermoacoustic blanket, which is a material normally used as inner lining of vehicles. Looking for the best way to join OXIDIZED PAN blanket with the thermoacoustic coating, three types of commercial adhesives with flexibility and heat resistance characteristics were researched and applied in this study. The results have shown that the specimens coated in both sides with OXIDIZED PAN blanket and jointed with gasket adhesive (3M®) and the specimens coated in both sides with OXIDIZED PAN blanket and jointed with Spray adhesive 76 (3M®) have had the lower values of flame propagation, attending the requirements of CONTRAN and International Standards. Therefore, these specimens can be used as an effective flameproof barrier in automotive vehicles.

EXPERIMENTAL PROCEDURES

Specimens' Preparation

To the sample preparation, the following materials were used: thermoacoustic blanket used in vehicles (Fig. 1), a non woven fabric made of OXIDIZED PAN fibers from textile materials, here named as OXIDIZED PAN blanket (Fig. 2) and commercial adhesives such as: 3M® gasket adhesive, contact adhesive (CASCOLA®) and spray adhesive-76 (3M®).

Seven types of specimens were tested according to standard UL-94[11]. Specimens of thermoacoustic blanket were tested as received. The other six panels were made using different combinations of OXIDIZED PAN blanket, thermoacoustic blanket and adhesives: A) two panels used the gasket adhesive3M®, one with a single face of OXIDIZED PAN blanket and other with two faces, B) two panels used the contact adhesive CASCOLA® one with a single face of OXIDIZED PAN blanket and other with two faces and C) two panels used the spray adhesive-76 /3M® one with a single face of OXIDIZED PAN blanket and other with two faces.

Figure 1: Thermoacoustic coating blanket used in vehicles.

The adhesive was applied manually in specimens. A thin adhesive layer was spread on the sample surface until formed a uniform coat and it was waited 2 minutes for partial drying of the adhesive. After this time, the parts were joined through manual compression.

Figure 2: OXIDIZED PAN blanket.

The specimens were cut out from the panels according to dimensions required by standard UL-94[11]. A total of 68 specimens with: 125 mm ± 2.24 x 13 mm ± 0.89x 13 mm ± 1.55 were prepared. Table 1 shows the different type of specimens used in flammability test.

Table 1: Specimens' types quantity and its symbols.

Specimen	Symbol	Quantity
Thermoacoustic blanket (as received)	TB	10
SF gasket adhesive3M®	SFG	10
DF gasket adhesive3M®	DFG	10
SF spray adhesive-76 /3M®	SF76	10
DF spray adhesive-76 /3M®	SF76	10
SF contact adhesive CASCOLA®	SFC	10
DF contact adhesive CASCOLA®	DFC	08

The specimens were labeled as following: quantity of OXIDIZED PAN blanket joint to the thermoacoustic blanket + adhesive type + specimen number; where: SF stands for single-faced, DF double-faced, G for gasket adhesive, 76 for spray adhesive and C for CASCOLA adhesive.

UL-94 Flammability Tests:

According to the Vertical burning test described in UL 94 VB[11], the specimens were marked 6 mm from the end to be fixed to the fastener, arranging it in a vertical position (Fig. 3). The Bunsen burner was switched on producing a blue flame of 20 mm high. To begin the experiment, the flame was placed for 10 seconds at the free end of the specimens. After this time, the flame was removed and flame propagation was observed until the extinction. If the specimens can drip molten or flaming material during the flame application, a small piece of cotton, approximately 50 mm², is to be brought into contact with the area below the Bunsen burner. Cotton helps to visually distinguish between flaming and glowing of particles generated from specimens. In this work, no particles were generated during the material burning.

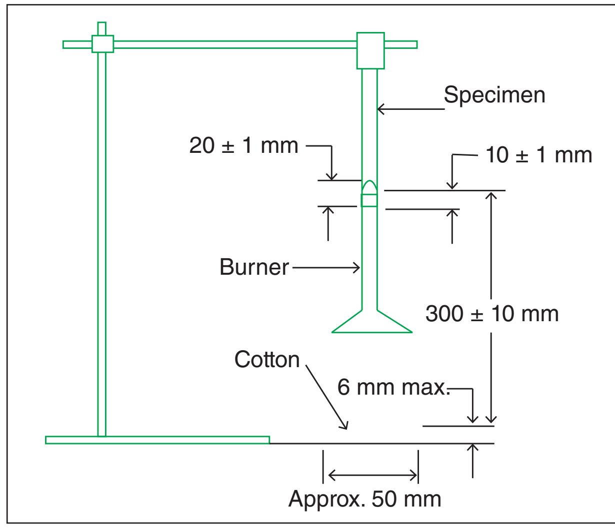

Figure 3: Apparatus experimental according to UL-94 VB[11].

The horizontal burning test was applied to materials that continue to burn and propagate the flame, according description of the UL-94 VB test[11], which implies the inability to classify them in this standard. Then, the UL-94 HB[11] (Horizontal burning) was used in order to classify the polymeric material by its burning speed. In this test, the specimens were fixed to the fastener by the free marking end and its longitudinal axis was placed in the horizontal position. The Bunsen burner was tilted at an angle of 45° (Fig. 4) and its flame was applied to the sample free end for a period of 30 seconds or until it reached the mark of 25 mm. The flame propagation period was timed to extinction or when it reached the mark of 100 mm.

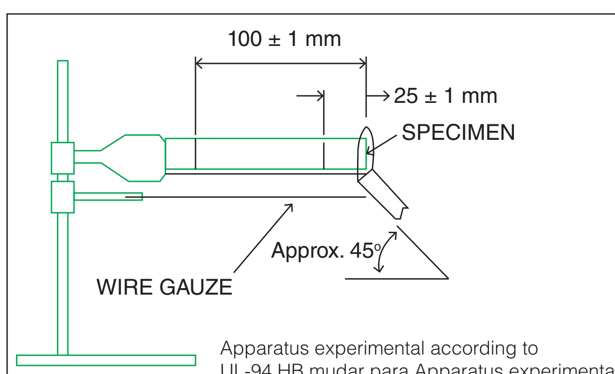

Figure 4: Apparatus experimental according toUL-94 HB[11].

Figure 4 shows the schematic for the horizontal flammability test and Fig. 5 shows the test running.

Figure 5: Running the UL-94 HB test.

Specimens Classification according to UL94 Standard

To define the material burning rate, the following Eq.1[11] was used:

$$V = (60 \times L) / t \quad (1)$$

where:
V = linear burning rate in mm/min;
L = damaged length on the sample, in millimeters;
t = time in seconds.

The criteria used to classify sample according to UL-94 VB[11] were:

- Classification V0 - The sum of the burning times of each sample type (5 specimens per type of adhesive/coating) must not exceed 50 seconds and the flame must not reach the fastener.
- Classification V1 and V2 - The sum of the firing times of each sample type (5 specimens per adhesive/coating type) must not exceed 250 seconds and the flame must not reach the fastener.

RESULTS AND DISCUSSIONS

Based on the UL-94 standard[11] and its methodology for data classification, it was found that the thermoacoustic blanket would technically attend the CONTRAN standards[2], but the data obtained by joining the OXIDIZED PAN blanket with the three adhesive types used in tests improved considerably the results, slowing the burning rate of specimens when they compared with the thermoacoustic blanket tested as received.

During the vertical tests, it was observed that the specimens did not attend the standard requirements, because according to UL-94 VB[11] if the flame reaches the fastener automatically, the vertical test must be disregarded. This behavior was verified for all specimens tested, even the specimens that had the double-faced OXIDIZED PAN blanket. The specimens that contained the contact adhesive showed the flame extinction and when classifying it in terms of burning time, they exceeded the maximum allowed time of 250 seconds, and did not be under any UL-94 VB classification[11].

To validate the test of all specimens the horizontal burn test was performed. It was possible to notice that the results were validated according to the values required by UL94[11].

During the tests, thermoacoustic blanket specimens (TB1, TB2 and TB3) were found to have higher burning rate (Fig. 6A) and thus a lower burning time (Fig. 7A) when compared to the other specimens tested. This behavior is due to the fact that the thermoacoustic blanket is composed of mixed textile fibers (polyester and wool) residues bound by polypropylene thermoplastic yarns that are highly flammable. These polymer materials have low heat resistance. According to ABINT[12] the polyester begins to melt from 220ºC, while the polypropylene melts from 170ºC and wool goes into ignition from 130ºC, so these materials are easily burned when subjected to a heat source.

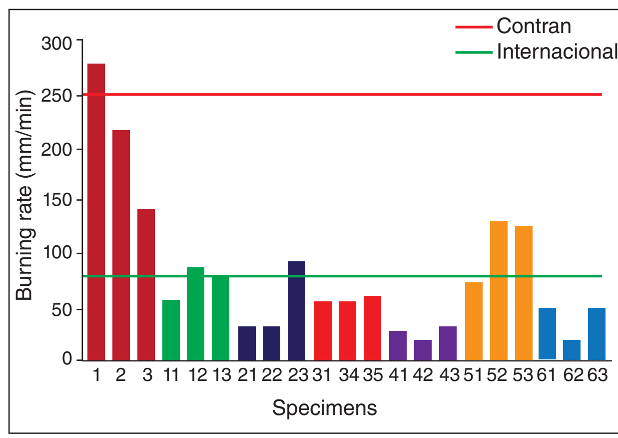

Figure 6: Specimens Burning rate: A) pure blanket, B) SF with gasket adhesive3M®, C) DF with gasket adhesive3M®, D) SF with sprayadhesive-76 /3M®, E) DF with spray adhesive-76 /3M®, F) SF with contact adhesive CASCOLA® and G) DF with contact adhesive CASCOLA®.

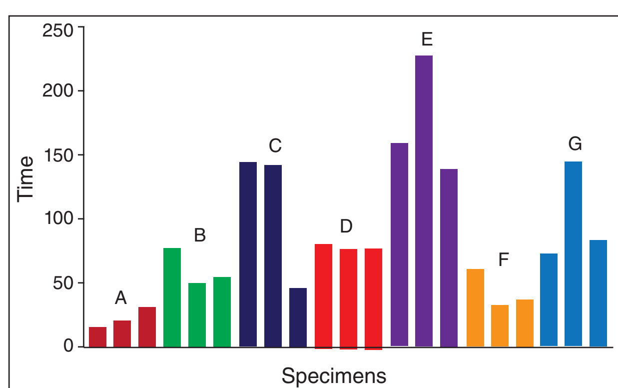

Figure 7: Specimens Burning Time: A) pure blanket, B) SF with gasket adhesive 3M®, C) DF with gasket adhesive3M®, D) SF with sprayadhesive-76/3M®, E) DF with spray adhesive-76 /3M®, F) SF with contact adhesive CASCOLA® and G) DF with contact adhesive CASCOLA®.

The specimen TB1 had its burning rate value (Table 2) above that allowed by CONTRAN[2], this is due to the fact that the thermoacoustic blanket is a mixture of polymeric materials without the concern of percentage of each material type throughout the final product; then, if the test portion contains a higher percentage of material with less heat resistance this will have more pronounced rate.

Table 2: Burning rates for each specimen according UL94 Standard[11].

Specimen	Designation	L (mm)	V (mm/min)
Thermoacoustic Blanket	TB-1 TB-2 TB-3	75 75 75	277.77 214.28 143.22
SF with gasket adhesive 3M®	SFG-11 SFG-12 SFG-13	75 75 75	58.45 87.27 77.96
DF with gasket adhesive 3M®	DFG-21 DFG-22 DFG-23	65 50 5	26.74 20.98 6.17
SF with spray adhesive-76 / 3M®	SF76-31 SF76-34 SF76-35	75 75 75	56.78 58.38 58.60
DF with spray adhesive-76 / 3M®	DF76-41 DF76-42 DF76-43	75 75 75	27.90 19.77 32.24
SF with contact adhesive CASCOLA®	SFC-51 SFC-52 SFC-53	75 75 75	75.44 129.98 125.94
DF with contact adhesive CASCOLA®	DFC-61 DFC-62 DFC-63	15 25 45	12.40 10.55 31.92

It was verified that all the six specimens types, DFG/SFG, DFC/SFC and DF76/SF76, had results with a burning rate values less than 250 mm/min (Table 2) attending the CONTRAN requirements.

Specimens DF76 had longer burning time (Fig. 7E) and even the burning rate being low it burned 100% (Fig. 6E). However, specimens DFG (Figs. 6C and 7C) and specimens DFC (Figs. 6G and 7G) also presented a better time × burning rate during the tests and the specimens did not burn completely before the flame was extinguished. These results indicate that the three specimens mentioned could be used as vehicles coating.

The OXIDIZED PAN blanket has been showed to be an excellent material to be used as flameproof coating. The specimens those were set up as double-faced with OXIDIZED PAN blanket had good results in flammability tests. Its use in conjunction with the thermoacoustic blanket associated with commercial adhesives was satisfactory since they met the standard requirements UL94[11], the CONTRAN requirements[2] and international organizations requirements[3], with burning rate results below those requirements indicated by the standards (Figs. 6C and 6G).

During the tests, specimens double-faced of OXIDIZED PAN blanket and joint with gasket adhesive (Fig. 8) had their flame extinguished before their total burn, as did specimens with double-faced of OXIDIZED PAN blanket and joint with contact adhesive (Fig. 9) where it was observed that OXIDIZED PAN blanket acted like a damper extinguishing the flame little by little.

Figure 8: Specimen double faced joint with gasket adhesive 3M® after test.

Figure 9: Specimen double faced joint with contact adhesive CASCOLA® after test.

CONCLUSION

Analyzing the results, it was possible identify which was the best material set up that could be used as anti-flame barrier in the vehicles interior. All specimens with double-faced OXIDIZED PAN blanket and joint with gasket adhesive or contact adhesive showed the burning rate below the specified values by CONTRAN and European standards. During the tests, these specimens maintained their physical structures without generate particles from burning.

Therefore, the materials used in this work could be applied daily not only as inner lining of vehicles, but also in other transport means, reducing the damage and the burning rate in a possible accident and so, increasing the possibility of survival or the vehicle recovery.

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