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Health Properties of Polyacrylonitrile Blankets Made with the Anti-Microbial Fibre Amicor Plus

Abstract

Between 2000 and 2002 a research project was carried out at the Institute of Natural Fibres, Poznań, on the application of various anti-microbial fibres, including the Amicor Plus fibre (supplied by Accordis Ltd., UK), in the manufacture of textile products. As a result of a comprehensive program of investigation, it was established that a 20% addition of Amicor Plus to the blanket cloth was enough to impart bioactivity to a blanket, and 40% Amicor Plus in the blanket pile inhibits the growth of the bacterium *Escherichia coli* and the fungi *Aspergillus niger* and *Trichophyton mentagrophytes*. The blankets manifested a high level of bioactivity whether Amicor Plus was added when non-dyed and dyed. Tests carried out at the Allergology Centre, Łódź, showed that blankets made with a proportion of Amicor Plus were an effective aid in treating allergy to the household mite.

Key words: polyakrylonitryle blanket; anti-microbial fibre; Amicor Plus; blanket with antibacterial and anti-fungal properties.

Introduction

The lifestyle of modern man, especially the ease of international travel and the new materials used for making clothes and articles for everyday use, contribute to the growth and rapid dissemination of various infections, dermatological diseases, and various allergies, including the allergy to mites [1]. One out of four people in Poland is allergic to one or more of these factors, but in 80% of cases the allergy is caused by mites living in bedclothes (blankets, quilts, cushions) [2,3]. The usual practice today is to treat the effects of the disease, but more and more frequently recourse is made to preventive measures, the more so as new-generation manmade fibres (polyester, acrylic, polypropylene, polyamide, polyvinyl-chloride) which have anti-microbial properties are available [4-8]. Textiles made from or with such fibres act preventively by inhibiting the growth of bacteria and fungi, thus reducing the population of mites and the production of their allergens. The production of anti-microbial fibres was started only in the late 1990s. For instance, the production of a new generation of the polyacrylonitrile fibres was started when the laboratories of Courtaulds Ltd developed a method of introducing into the fibre mass oily anti-microbial agents in the form of microcapsules ranging in size from a few to several micrometers, with 1 µm walls [9]. Based on this method, Acordis Ltd, UK, is manufacturing two modified PAN fibres, Amicor and Amicor Plus, of which the first has antibacterial properties and the second has a combined antibacterial and anti-fungal activity. Acordis has

been granted authorisation, according to Öko-Tex Standard 100, to use the Öko-Texmark for Amicor Plus [10].

These properties are imparted to the fibres by microcapsules of oily medical preparations which are introduced to the fibre mass. The medical preparation is slowly released onto the fibre surface by diffusion, and provides a permanent thin layer of active substance on the surface of the textile product. The preparations added to Amicor Plus are Triclosan, which is antibacterial, and Tolnaftate, which is anti-fungal. The physical and mechanical properties of Amicor Plus are similar to those of the standard PAN, and the blending possibilities are also similar [9].

In a research project started in 2000 jointly by the Institute of Natural Fibres and the company Zwoltex, Amicor Plus was used in a blend with PAN for the manufacture of sanitary blankets with anti-microbial properties [11].

Scope of research

The general aim was to determine the effect of the Amicor-Plus component on the anti-microbial and anti-mite properties of the blankets produced. The following aspects were investigated:

- the effect of dyeing the Amicor Plus fibre on its anti-microbial properties;
- the manufacture of yarns from blends of standard PAN and Amicor Plus in various proportions, and making the yarns into woven blanket fabrics;
- determining the optimum proportion of the anti-microbial fibre in the

blanket for the best anti-bacterial and anti-fungal effect;

- the effect of the use of blankets made with Amicor Plus on the health condition of patients with mite allergy.

The microbiological tests of the Amicor-Plus fibre and blankets were performed at the accredited Microbiological Laboratory of the Institute of Manmade Fibres, Łódź. The anti-mite properties of the blankets made with Amicor Plus were tested at the Allergology Centre, Łódź.

Materials

The materials tested were:

- the anti-microbial fibre Amicor Plus 3.3 dtex and 6.7 dtex; certified under Öko-Tex Standard 115 complying with European Standard EN71, part 3; and British Standard BS5736 [14].
- woven blanket cloth of area weight 400 g/m², experimentally made with 20%, 30%, and 40% Amicor Plus in the blanket pile.

The reference materials were PAN fibres Dralon 3.3 dtex and 6.7 dtex, and a woven fabric made with these fibres.

Methods

Microbiological tests

The microbiological tests of the Amicor Plus fibre, non-dyed and dyed, and the blanket fabrics with various proportions of this fibre, were based on the following standards:

1. Japanese Standard JISL 1902; 1998 'Testing method for antibacterial of textiles' – test of anti-bacterial properties, using:

- a quantity test;
 - a control organism, *Escherichia coli* (ATCC 11229).
2. Swiss Standard SN 195921;1994-00-00 'Textile fabrics – determination of the antimicrobial activity – agar diffusion plate test' – test of anti-fungal properties, using:
- a quantity test;
 - control organisms *Trichophyton mentagrophytes* LOCK 0572, and *Aspergillus niger* (ATCC 6275)

Performance test of blankets made with Amicor Plus

The test of the blankets' practical resistance of to allergens was based on practical performance tests and analysis under ambulatory clinic conditions at the Allergy Centre, Lodz. The test involved 28 patients from 3 to 76 years old with symptoms characteristic of mite allergy. For practical use we selected blankets made with 20% and 40% of Amicor Plus. Each variant of blanket was used by 14 persons individually for 1 month. Each day, while using the blanket, the patient evaluated the intensity of his/her allergic symptoms on a scale, grading the intensity from 0 to 10 (maximum intensity). In addition, the population of allergens in the patient's bed was determined by the Acarex test before and after use of the blanket [12].

Experiments

Dyeing of Amicor Plus

The fibre Amicor Plus and the reference fibre Dralon were dyed under laboratory conditions with the following dyes:

- Astrazon - Bayer (Germany);
- Oleacryl - Olea (France).

The dyeing process was similar for the PAN fibre. The recipes for dyeing Ami-

Table 1. Dyeing recipes for Amicor Plus and Dralon.

Supplier	Dyeing recipe	Liquor ratio
Bayer (Germany)	0.008% Astrazon gelb GLE 200% 0.008% Astrazon blau BG 200%	1:30
Olea (France)	0.005% bleu Oleacryl RP-2R 0.03% jaune Oleacryl RP-G	1:30

Table 2. Blends for yarns with various proportions of Amicor Plus.

Variant 1 Yarn with 20% Amicor Plus	Variant 2 Yarn with 30% Amicor Plus	Variant 3 Yarn with 40% Amicor Plus
Amicor Plus 3.3/63 – 10%	Amicor Plus 3.3/63 – 15%	Amicor Plus 3.3/63 – 20%
Amicor Plus 6.7/63 – 10%	Amicor Plus 6.7/63 – 15%	Amicor Plus 6.7/63 – 20%
Dralon 3.3/60 – 64%	Dralon 3.3/60 – 56%	Dralon kolor 3.3/60 – 48%
Dralon 6.7/60 – 16%	Dralon 6.7/60 – 14%	Dralon kolor 6.7/60 – 12%

Table 3. The raw-material composition of the yarns used in the fabric.

Type of yarn in fabric	Linear density of yarn, tex	Raw-material composition of yarn in fabric			
		Reference fabric	Variant I	Variant II	Variant III
Warp	50	Cotton 100%	Cotton 100%	Cotton 100%	Cotton 100%
Weft	250	Dralon 100%	Amicor Pl. 20% Dralon 80%	Amicor Pl. 30% Dralon 70%	Amicor Pl. 40% Dralon 60%

cor Plus and Dralon to a pale-blue colour are presented in Table 1.

Making yarn with Amicor Plus

To determine the optimum proportion of Amicor Plus in the blanket, 250 tex yarns containing 20%, 30%, and 40% of the fibre were produced. The raw-material composition of the blends is given in Table 2.

All yarns were manufactured on a processing line comprising:

- an opening and blending line composed of machines and devices supplied by BeFaMa and Falubaz;
- a card set (type CW 642-08/E), and a sliver-forming and taking-up device (type CZ 44) supplied by BeFaMa;
- an Elitex draw frame (type PS-KDV 2);
- An Elitex rotor-spinning machine type BDA 12 N.

Making the blanket cloth

Three variants of a blanket cloth of an area weight of 400 g/m² were made on a 300-cm wide Nuovo Pignone rapier loom. The raw-material composition of the yarns used for the three variants is described in Table 3.

Results and discussion

Effect of dyeing on the anti-microbial properties of Amicor Plus

The anti-bacterial properties of Amicor Plus, as manifested before and after dyeing, are described in Table 4. The microbiological tests of Amicor Plus 3.3 dtex and 6.7 dtex which were performed showed that after dyeing, the bacteriostatic and bactericidal activity of the fibres remained at a high level.

The results of the tests for inhibiting the growth of *Aspergillus niger* on Amicor

Table 4. Antibacterial activity of Amicor Plus after dyeing (against of *Escherichia coli*).

Dyes	Fibres	Time, h	Count of bacteria on sample, cfu*		Bacteriostatic activity log (B/C)		Bactericidal activity log (A/C)	
			before	after	before	after	before	after
			dyeing		dyeing		dyeing	
Astrazon	Dralon – control sample /A/	0	3.2×10 ⁵	2.3×10 ⁵	-	-	-	-
	Dralon – control sample /B/	24	9.5×10 ⁷	1.6×10 ⁸	-	-	-	-
	Amicor Plus 3.3 dtex /C/	24	2.6×10 ⁵	6.0×10 ⁴	2.6	3.4	0.1	0.7
	Amicor Plus 6.7 dtex /C/	24	2.0×10 ⁴	4.7×10 ⁴	3.7	3.5	1.2	0.8
Oleacryl	Dralon – control sample /A/	0	3.2×10 ⁵	2.3×10 ⁵	-	-	-	-
	Dralon – control sample /B/	24	9.5×10 ⁷	1.7×10 ⁸	-	-	-	-
	Amicor Plus 3.3 dtex /C/	24	2.6×10 ⁵	1.7×10 ⁵	2.6	3.0	0.1	0.1
	Amicor Plus 6.7 dtex /C/	24	2.0×10 ⁴	5.2×10 ⁴	3.7	3.5	1.0	0.7

* - colony forming units; the sign (-) indicate that the control samples are not characterized by bacteriostatic and bactericidal activity.

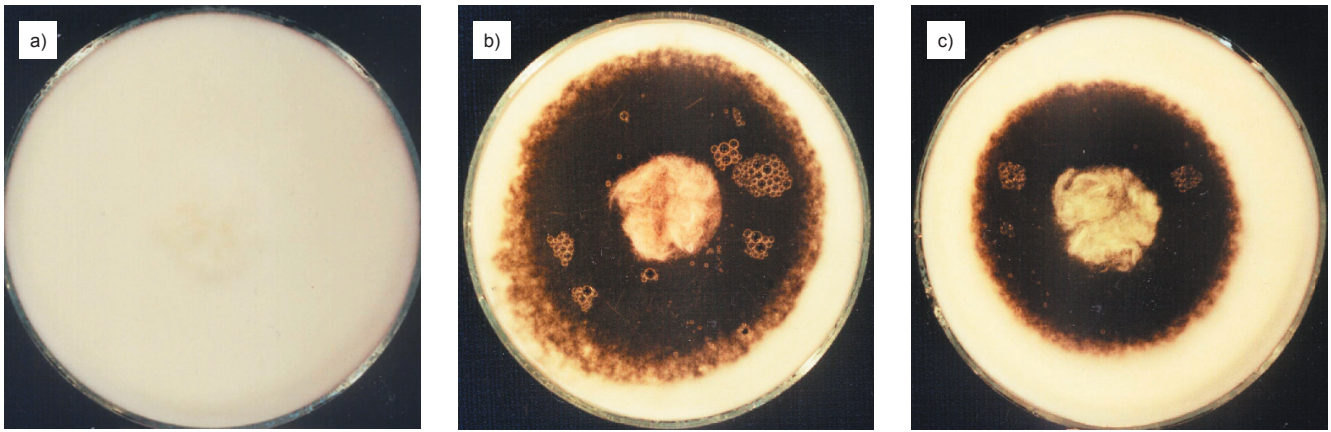


Figure 1. *Trichophyton mentagrophytes* zone of growth inhibition after 7 days of exposure to dyed Dralon and Amicor Plus 6.7 dtex respectively; Dralon St. after dyeing with Astrazon - Bayer (a), Amicor Plus after dyeing with: Astrazon - Bayer (b), Oleacryl - Olea (c).

Plus after dyeing shows that while there was no growth directly on the fibres, no growth-inhibiting zone could be clearly observed. Therefore, in relation to this fungus, the fibre was ranked as 'medium'. However, it showed an excellent inhibition of the growth of *Trichophyton mentagrophytes*. After dyeing, Amicor Plus demonstrates a high fungicidal activity, forming a fungus growth inhibition zone around it both when dyed with Bayer or Olea dyes. On the other hand, the Dralon fibre after dyeing remains non-inhibitive to fungi. The high resistance of the Amicor Plus fibre after dyeing to the growth of *Trichophyton mentagrophytes* is demonstrated by the photographs of plates with Amicor Plus fibres made after 7 days of the test (Figure 1).

Effect of Amicor Plus proportion in blanket cloth on its anti-microbial properties

The results of the tests of the bacteriostatic and bactericidal activity of blankets made with various proportions of Amicor Plus are presented in Table 5.

The results of tests of the bacteriostatic and bactericidal activity of blankets made with various proportions of Amicor Plus showed the following relationship between the anti-bacterial activity and proportion of the fibre in the blanket cloth; the higher was the proportion of Amicor Plus in the blanket pile, the smaller was the growth and count of bacteria on the test sample.

Regarding the anti-fungal properties of blankets made with varied proportions of Amicor Plus, the tests showed that proportions between 20 and 40 percent created comparable growth-inhibiting conditions for *Trichophyton mentagrophytes*

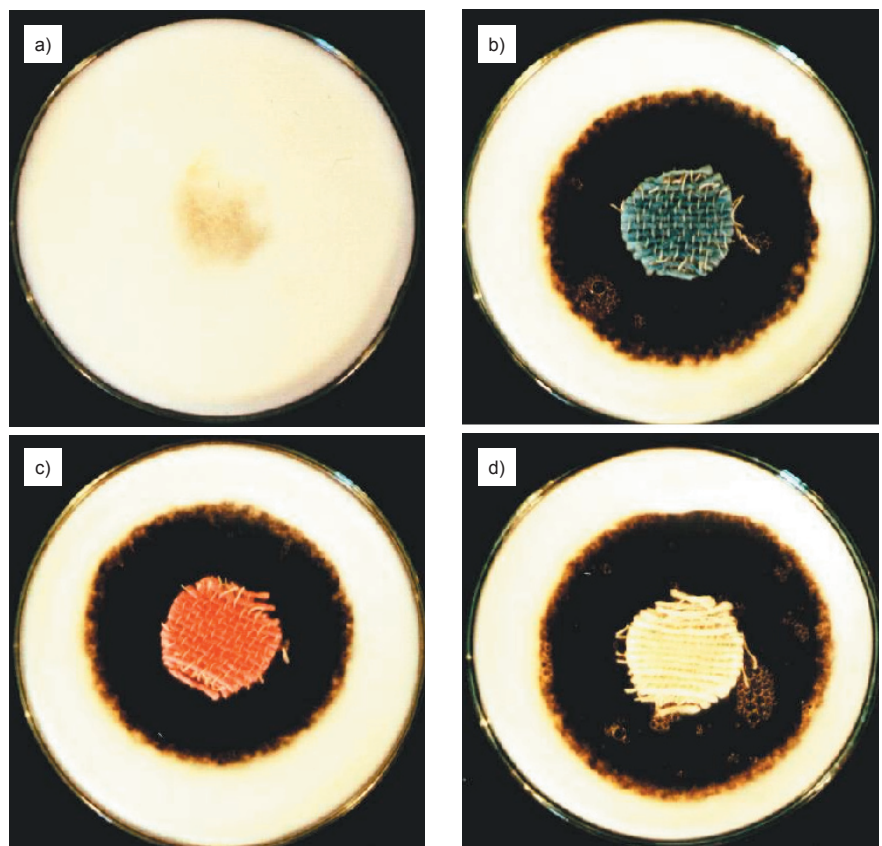


Figure 2. *Trichophyton mentagrophytes* zone of growth inhibition after 7 days of exposure to blankets made with various proportions of Amicor Plus; a - Control sample (100% Dralon), b - Variant I (20%), c - Variant II (30%), d - Variant III (30%).

Table 5. Antibacterial activity of blankets made with different proportions of Amicor Plus (against *Escherichia coli*).

Weft in the fabrics	Time, h	Count of bacteria on sample jtk*	Bacteriostatic activity log (B/C)	Bactericidal activity log (A/C)
Dralon 100% – control sample /A/	0	2.8×10^6	-	-
Dralon 100% – control sample /B/	24	7.4×10^7	-	-
Amicor Plus 20% + Dralon 80% /C/	24	2.2×10^6	1.5	0.1
Amicor Plus 30% + Dralon 70% /C/	24	1.2×10^6	1.8	0.4
Amicor Plus 40% + Dralon 60% /C/	24	5.2×10^5	2.2	0.7

*- colony-forming units.

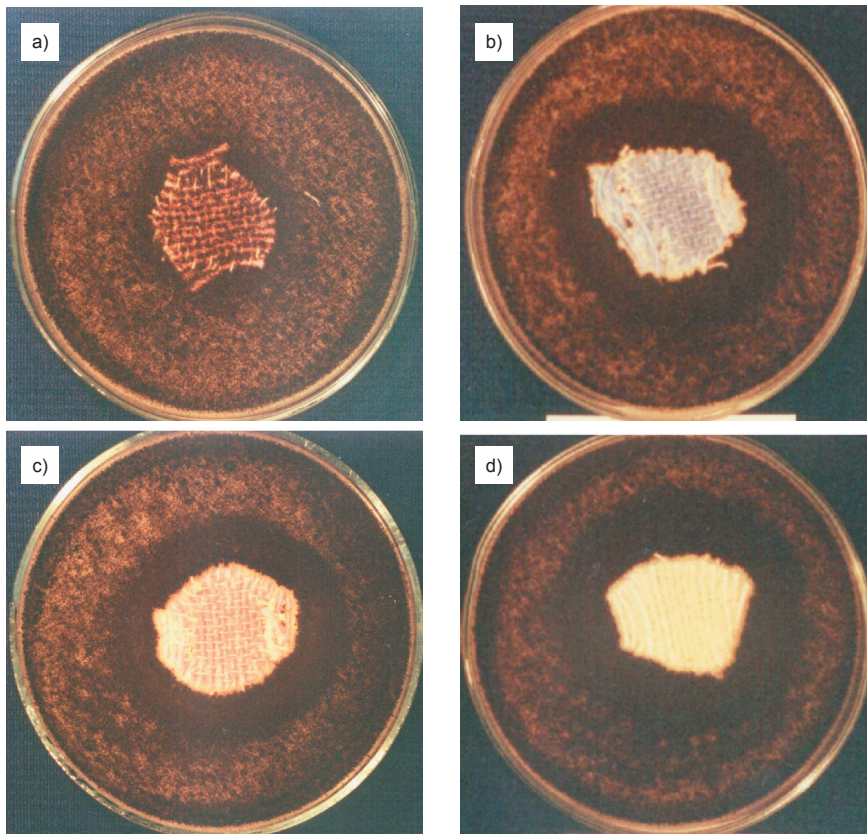


Figure 3. *Aspergillus niger* zone of growth inhibition after 7 days of exposure to blankets made with various proportions of Amicor Plus; a - Control sample (100% Dralon), b - Variant I (20%), c - Variant II (30%), d - Variant III (30%).

and *Aspergillus niger*. Photographs of Dralon/Amicor Plus samples made after 7 days of growth of the control organisms are shown in Figures 2 and 3. In the case of the control organisms, *Trichophyton mentagrophytes* produced a much greater growth inhibition zone than *Aspergillus niger*.

Practical performance test of blankets made with Amicor Plus

For the practical performance test, we selected blankets of an area weight of 400 g/m², whose pile contained Amicor Plus in proportions of 20% and 40%. Before beginning the test, the group of 28 test patients had a total of 127 points

according to the visual evaluation of the symptom scale (4.5 points per patient on average). After using the blankets for one month, the number of points was reduced to 68 (2.4 points per patient), while no significant differences were observed in the general feeling depending on the proportion of Amicor Plus in the blanket. A significant improvement in general feeling was declared by 61% of the test patients suffering from mite allergy [12]. The counts of allergens in the patients' beds, made before and after the monthly use of Amicor Plus-enhanced blankets, confirmed that the growth of the mite population responsible for the allergy was inhibited [13]. The level of allergen incidence in the test group is shown in Figure 4.

The tests made at the Allergology Centre showed that the blankets made with Amicor Plus reduced the high and medium concentrations of allergens in the patients' beds. The high concentration occurred with 46% of the test patients. No medium concentration of allergens occurred, although 40% had a low concentration, and no allergens were found with 14% of the patients. The results of the tests are correlated with the reports of general feeling, and provide evidence that a 20% content of Amicor Plus was enough to make the blanket helpful in the treatment of allergy to mites, and in preventing this allergy. There is also evidence that the blankets do not induce any allergic reactions of the skin.

Conclusions

1. The bioactive fibre Amicor Plus can be used in blends, both non-dyed (raw-white) and dyed to any colour, since the dyeing process does not have any negative effect on the antimicrobial properties of this fibre.
2. There are no technological problems with the production of blend PAN/Amicor-Plus yarns with a linear density of 250 tex, or with making the yarns into blanket fabrics of an area weight of 400 g/m².
3. The blankets made with 20%, 30% or 40% of Amicor Plus have antibacterial and anti-fungal properties. The microbiological activity of the blankets can be characterised as follows:
 - antibacterial activity is more intensive, when the proportion of Ami-

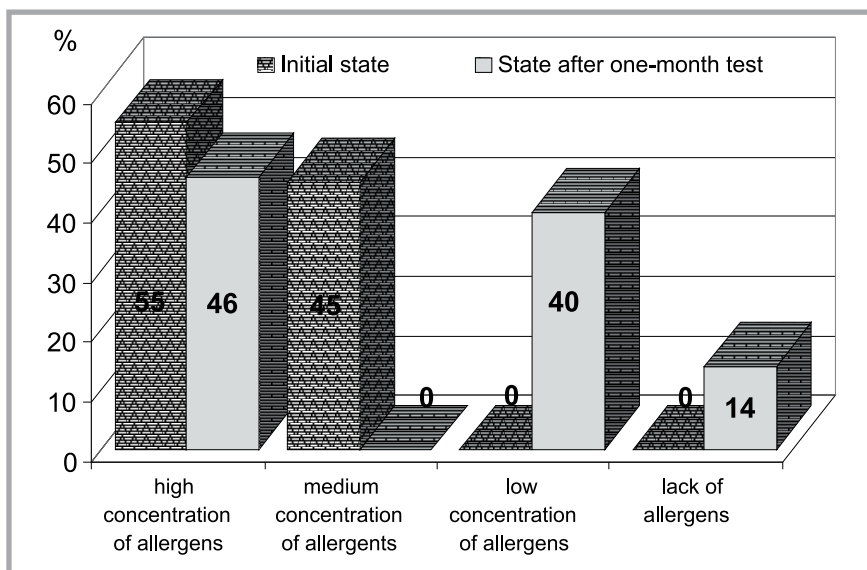


Figure 4. Percentage of patients in the test group in whose beds allergens of various levels of concentration were found before and/or after the use of Amicor-Plus blankets.

cor Plus is higher. If the blanket cloth is made with 40% Amicor Plus, its bacteriostatic activity is 1.5 times higher, and its bactericidal potential is 7 times higher than if the Amicor-Plus content is 20%;

- inhibition of the growth of the fungi *Aspergillus niger* and *Trichophyton mentagrophytes* on blankets is already at a higher level, after the addition of 20% of Amicor Plus to the blanket.

4. According to the practical performance tests made by the Allergology Centre, the blankets made with 20% and 40% Amicor Plus inhibit the growth of mites, and are therefore suitable for use in preventing mite allergy. They aid the treatment of mite allergy, and do not induce any allergic reactions of the skin.



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