Journal of Achievements in Materials and Manufacturing Engineering

VOLUME 28
ISSUE 1
May
2008

Aramid-silicon laminated materials with special properties – new perspective of its usage

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Received 27.02.2008; published in revised form 01.05.2008

Materials

ABSTRACT

Purpose: Development of the manufacturing technology of aramid-silicon laminated material.

Design/methodology/approach: Aramid-silicon laminated material was made by method of manual formation of laminates, that is impregnation of reinforcement with matrix, to hardening silicone process using hardening methods connect with hot. Created material was being observed by using MEF4A light-microscope of Leica company at 25-500x magnification.

Findings: The results show that the preliminary manufacturing technology of aramid-silicon laminated materials allows to create a material with specific and special properties. Aramid silicone laminate could be attractive alternative for composite material used in medical and others purposes.

Research limitations/implications: Carried out investigations show the problem with cautioning and ageing which are very important in having proper percentage of intensifier in developed material.

Originality/value: Taking into account the material specific properties one can suppose that the aramid-silicon laminated material would be useful in medicine. Aramid silicone laminate could be attractive alternative for composite material used in medical and others purposes.

Keywords: Composites; Engineering polymers; Biomaterials; Technological devices and equipment; Aramid; Ssilicone; Application

1. Introduction

Significant role in civilization development have new engineering materials. A progress in this discipline is stimulated by military needs, medicine and also others discipline connected with the industry.

New functional materials guarantee advance in science and technology [6-10]. Among many kinds of materials an important role fulfill composite on polymer warp. The are irreplaceable in many cases [1-12]. It conclude from a variety of the polymer warp and many ways to reinforce: from clean polymer to glass, graphite or carbon fibre etc. In that way it is possible to select those functional properties which meet the expectations. Modification of the surface layers – interference into the polymer structure (macro and micro scale) is one more way to obtain these results. Similar to others engineering materials about implementation decide possibility of composite manufacturing, specified requirements of all components ether grow up this problem. Specification of application given additional condition which limit choose of polymer warp and strengthening material particular in electronic, air crafting, motorization and most of all in medicine. Medicine application of composite materials are conditioned by bio-conformity with strength and elasticity requires.

Among great group of polymers fundamental role in medicine application feature silicones and fibres. In XXI century it is impossible to live without plastic materials. To majority of them base monomer molecule is four-valued carbon atom. Silicones are different because above-mentioned base monomer molecule is silicon, Si (Fig. 1). Silicones materials was developing in research process of materials which fulfill higher requirements. Medicine silicones are produced with higher chemical cleanest discipline than technical silicones. Produce process guarantee lack presence of substation which could react with human body and product inflammatory states, allergic reaction or after long contact cell mutation. Prove of that is usage silicones like implants and scar dressing [6-16]. Medical silicones are ones of few substation with high bio-conformity with human body which have impact to the attractiveness of this material.

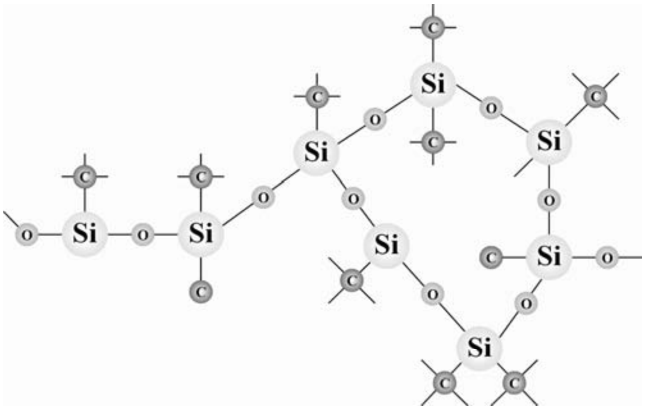

Fig. 1. The scheme of the structure of silicone [1]

However if we looking for fibres which could be used with success in width understand of medicine it is necessary to pay attention on commonly used in technology aramid fibres belonging to aromatic polyamide group. These materials are characterize by high mechanical strength on tenacity, low elongation and low mass, these fibres have numerous technical use to products which transmits high mechanical load and resistant to material consumption and chemical environment. Use of aramid fiber in alloplastics will cover needs different chirurgical disciplines for implants with high mechanical strength. Ambiguous is biological interaction and bio-stability of aramid, which investigate on Medical Academy in Wroclaw [25-30].

Bogusława Żywicka who working in Department of Experimental Chirurgic and Biomaterials Investigation, the same University investigate bio-conformity aramid fibres in compare with common use polyester fibres with known biological affect. Investigation include in first phase: define physicochemical properties of hemolytic actions, cytotoxine grade, reactivity of water extract of endodermis and in second phase: tissue reaction after implantation estimation in beginning and further period, general structure and local induction pro-impetuous cytokinins IL1 and IL-6 after implantation and fiber resistance on bio-corrosion.

Results of investigation exhibit very favorable, certify that aramid fibres cause minimal tissue reaction comparable to polyester fibres and did not cause local or general structure pro-impetuous cytokinins IL1 and IL-6 stimulation. Aramid fibres exhibit higher static and dynamic mechanical strength in compare with polyester fibres, they do not bio-corrode and could be use to increase mechanical strength of medical material or like independent bio-material under high mechanical loads [23-25].

Taken under consideration both above-mentioned polymer material groups we could expect that these materials could made together neutral biomedical material, but we have to remember that silicones are in gel or elastomer form and they are not used like warp to produce laminate. To manage it we have to fulfill wettability fiber by warp condition which guarantee adequate adhesion and mating. Common use in medicine silicones have got to high viscosity to be able to supersaturate fiber. This problem do not apply to industrial applications, where elastic laminates on glass fiber and silicone base are good isolators.

It is possible to solve this problem by inserted diluents decreasing viscosity of base resin. It makes necessary to multilayer settings silicone resin solution to deliver diluents to all layers. Leaving small amounts of volatile substations between fibers will produce pores and bubbles deterioration adhesion resin to fiber. In that way the problem of impregnation and hardening emerges.

The aim of the following paper is developing a technology of composite production: elastic aramid-silocone laminate.

2. Material

Components used for laminate production are:

- Aramid fabric manufactured by Havel Composites PL. SP. Z O.O.: CCC120 with Basic weight 36 g/m^2, 61 g/m^2 and 173 g/m^2; technical date are shown in Table 1,
- Medical silicone that consists of 50% silicone and codissolving ingredients: mineral sirits and isopropanol (iPA) with concentration 70% and 30%.

Aramid fabric was used because of its strength properties, heat resistance, chemical resistance, high elasticity modulus, low flammability and good ratio of strength to density. Another factor was recently led researches of degree of biocompatibility aramid fibers with living tissue that have been mentioned in [13-22].

Medical silicone, that is available on the market has been chosen basically for its low adhesiveness that barely 139 cSt, that has essential impact on composite production – it simplify nasączania procedure, eliminates additional dilute of resin. A an important role has biocompatibility of discussed substance that influence the ability of creation bioneutral

3. Laminate forming

Samples has been created by method of manual formation of laminates, that is impregnation of reinforcement with matrix. This method has been chosen because it is simple and low cost production unit. Forming process of laminate was prepared in room temperature under normal pressure.

Table 1.
Technical information about aramid fabric manufactured by Havel Composites PL. SP. Z O.O

TECHNICAL INFORMATION \ KIND OF FABRICS	FABRIC 36	FABRIC 61	FABRIC 173
Basis weight [g/m^2]	36	61	170
Thickness fabric [mm]	0.10	0.12	0.16
Matrix	Aramid 49 T 965 21,5	Aramid 49 T 965 21,5	Aramid 1210 dtex type 2200
Plot	Aramid 49 T 965 21,5	Aramid 49 T 965 21,5	Aramid 1210 dtex type 2200
Mass density fabric [g/m^3]	1.45	1.45	-
Mass density linear [Tex]	22	22	-

Type of plait for all kind of fabrics: linen

Combination of both ingredients in laminate is a melting fibers of the fabric into hardened matrix (silicone), what provides obtaining discomposed material. One can see clear surface between components – micro built of is heterogeneities [3].

Taking ingredients under consideration it would be ideal if silicon adhere to reinforcement on the entire area and adhesion force between silicone and aramide fibers is at least as big as cohesion force in silicone itself. But actual situation is that relation existing on the adhere surface are much more complicated and determined by following factors:

- Chemical composition of the reinforcement (in particular outer layer)
- Grade of hydration of fibers surface,
- Type and quantity of surface defects,
- Type of surface preparation fibers and procedure of spreading,
- Chemical built, composition and properties of the silicone,
- Manufacturing technology and hardening of laminate [6-12, 16].

All mentioned above factors are strictly connected one to each other and influence on the relation type between reinforcement and matrix in adhere point on the same level.

With the problem of impregnation reinforcement of matrix (silicone resin) is strictly connected. Hardening plastics has reactive groups in macromolecule and in reticulation factors and/or temperature they undergo chemical reaction of reticulation, which result in 3D structure [1-10]. Nowadays one can distinguish various methods of hardening:

- Methods with initiators and/or temperature:
- Hardening in room temperature
- Hardening in increased temperature
- Radiation methods:
- Hardening with UV light
- Hardening with visible light
- Hardening with microwave radiation
- Hardening with high energy radiation [6-13].

Composite harden with heat is a classical example of binder for laminates manufactured with preimpregnation. Adhesiveness of this binder decreases when using typical volatile dissolving, which simplify technological process and do not integrate in final material properties.

General principle obligatory in processing such of composition is complete elimination solvent before resin hardening. Using them in technological processes when epoxide composition is coating in thin layer on base, that why in adequate high temperature all volatile substations could evaporate before laminate hardening in lower temperature. Solvent elimination before resin hardening produce numerous pores and impair laminate properties.

Taken under consideration above mentioned factors and instructions to technological process of aramid silicone laminate manufacturing have to run in following way.

On the beginning from aramid fabric with basis weight 36, 61 and 173 g/m^2 the 5x5 cm samples has been taken (Fig. 2). Samples has been absorbed with silicone, the process was repeat five times to get ideal smooth surface. After each absorbing process the solvent has to evaporate to avoid pores presents which could not release before final silicone hardening. In additional particular attention has been given to do correct first absorbing process, supervise to get total penetration strain hardening by warp (Fig. 3-5). Good warp adhesion to strain hardening material have significance meaning to ready material properties.

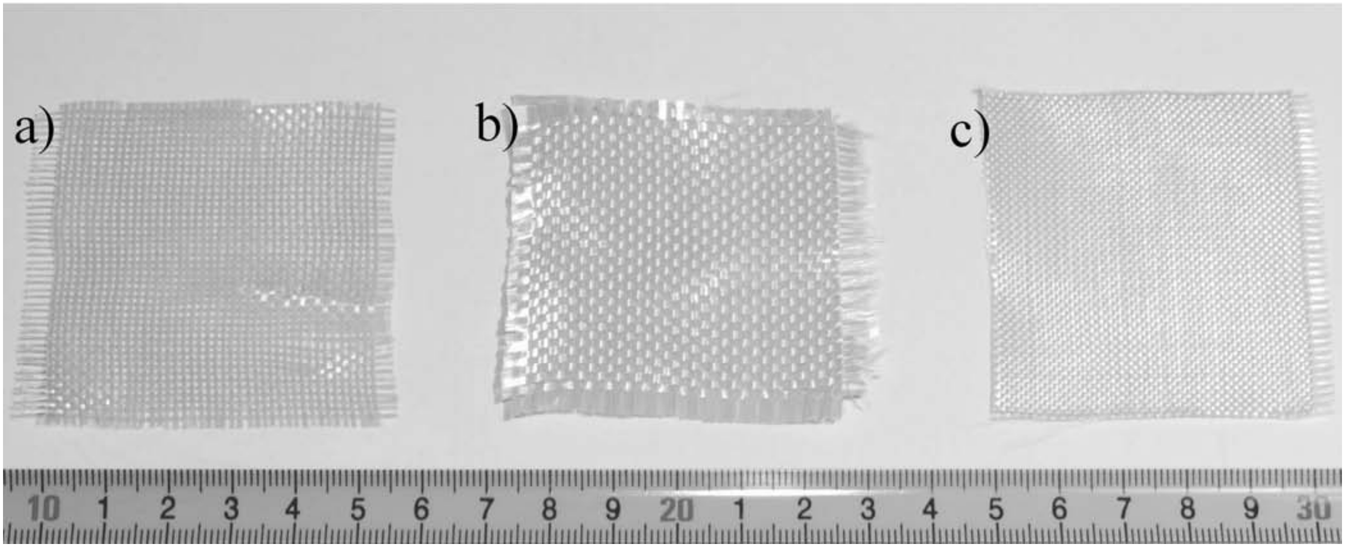

Fig. 2. The survey of prepared samples taken from aramid fabric with basis weight a) 36g/m^2; b) 61 g/m^2; c) 173 g/m^2

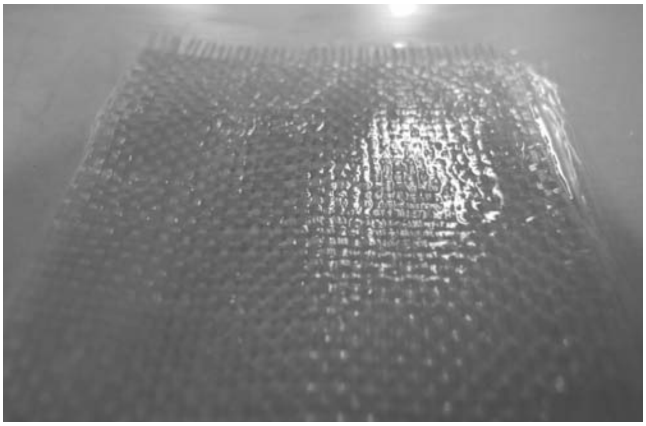

Fig. 3. The survey of sample after one absorbing proces, sample made base on aramid fabric with basis weight 36 g/m^2

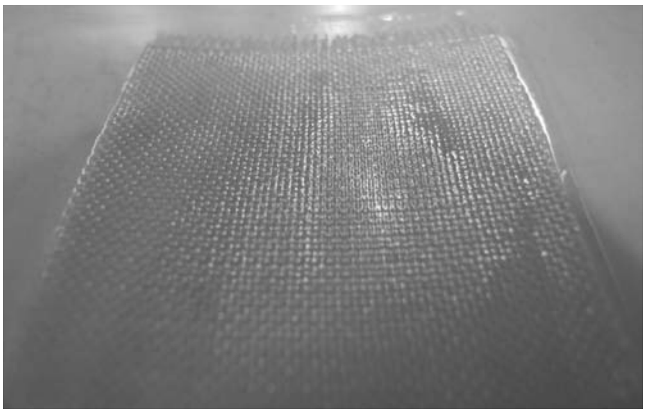

Fig. 4. The survey of sample after one absorbing process, sample made base on aramid fabric with basis weight 61 g/m^2

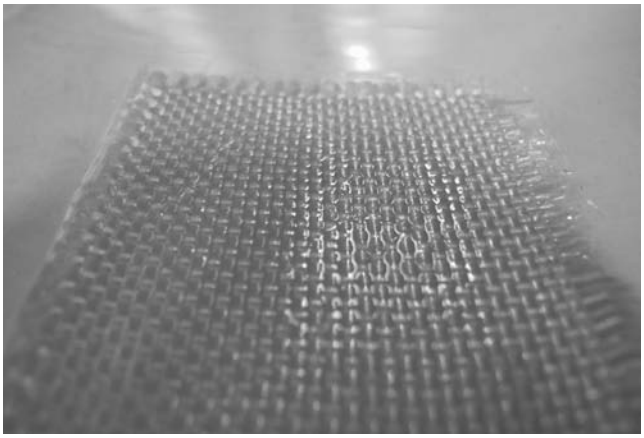

Fig. 5. The survey of sample after one absorbing process, sample made base on aramid fabric with basis weight 173 g/m^2

Hardening silicone process proceed in 70 ºC temperature, in normal pressure, with lower 20 to 30% humidity. Samples has been placed in heat chamber KC 100/200. After five days since samples was placed in drying chamber, a samples surface has been visual checked for completed hardening in outer parts (Fig. 6). Next samples has been removed from base rotated about 180º and left for three days longer in the drying chamber.

After eight days the material was ready – aramid silicone laminate with specific properties and diversified surface roughness (Fig. 7).

4. Research

Samples has been properly prepare this is clean and placed on special made stand to avoid sample over-exposure (Fig. 8). Visual observation was made on Leica MEF4A optical microscope with magnification 25 – 500x (Fig. 9, 10).

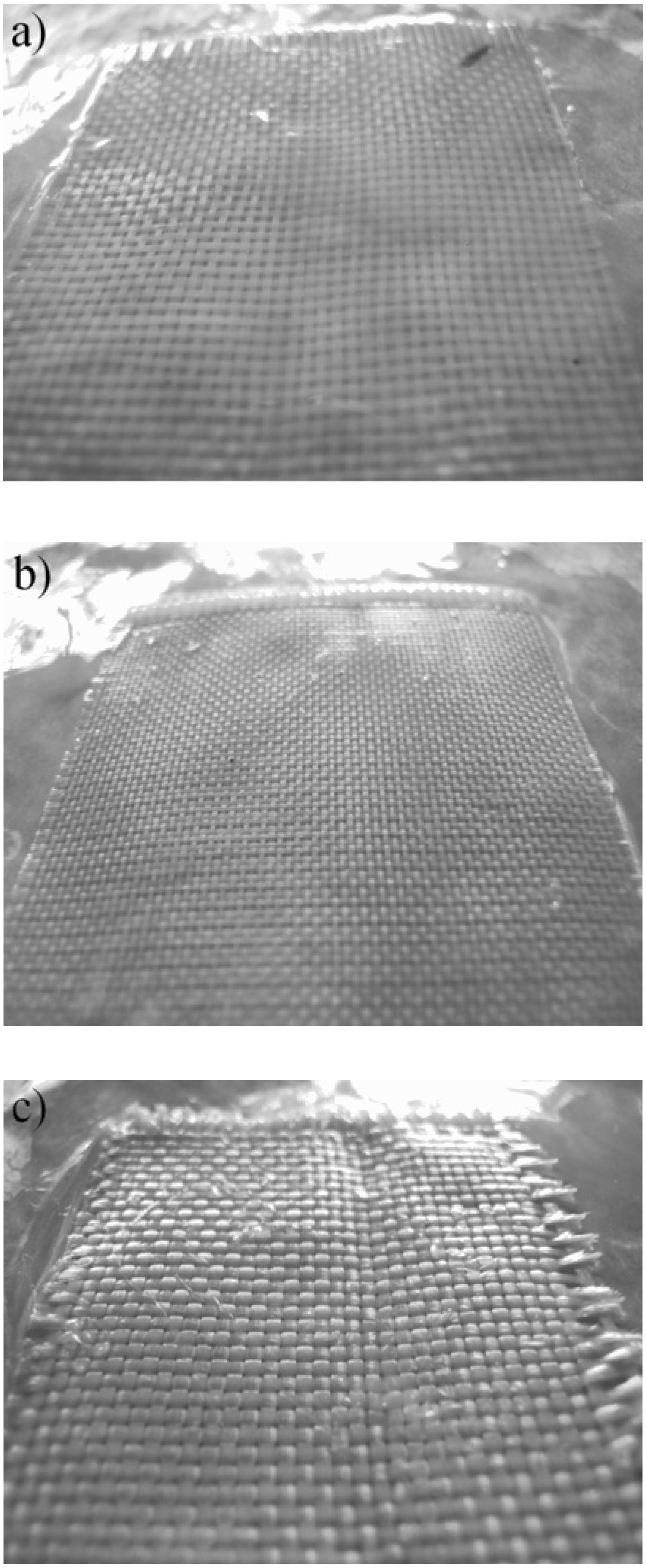

Fig. 6. The survey of samples in hardening process: c) 173 g/m^2

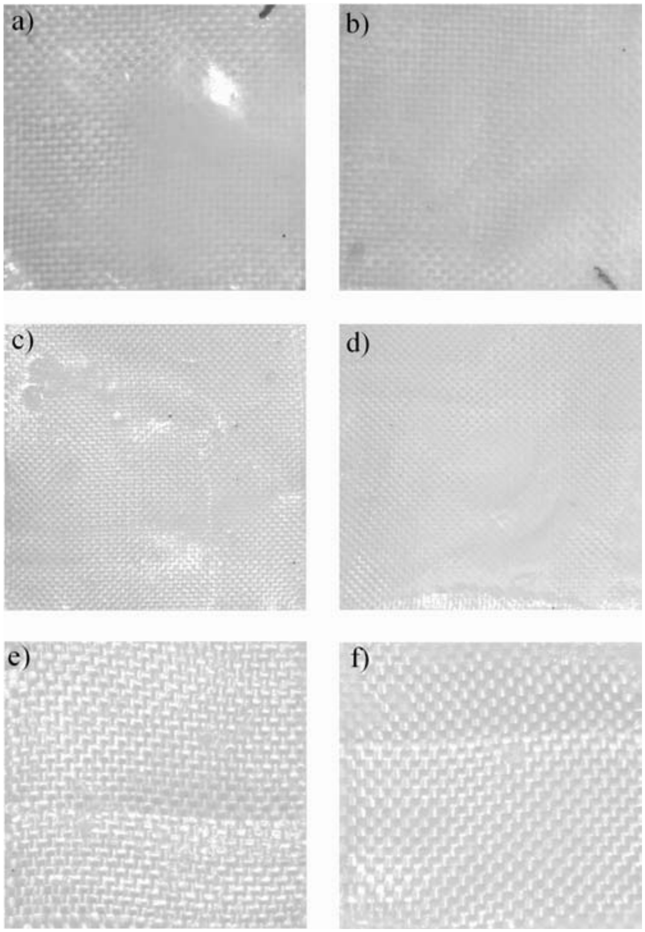

Fig. 7. The survey of samples after hardening process: a-c) „Uper” part, d-f) „Lower”part

Additionally visual observation of samples has been made to identify possible surface defect like:

- ripple marks,
- surface holes,
- vesicles made by bad silicone adhesion,
- cracks,
- uncovered impregnated hardening [3].

5. Results

The result of the research is shown in Fig. 9 and 10. One can notice that obtained composite has vitiated degree of fabric impregnation, upper layer has been precisely impregnated with matrix and perfect surface has been obtained (very small roughness).

In the Fig. 9b, 9c one can see perfectly impregnated fabric with a thin silicone surface layer.

Bottom layer shows much more roughness in comparison to upper layer – this can be noticed in Fig. 10b., the thinnest silicone layer was obtained in the heaviest sample of reinforced fabric (Fig. 10c).

Microscope research enabled to identify surface holes, that are included to surface defects regarded materials (Fig. 9a, 9b, 9c). This defect shows that evaporate of solvent from silicone resin process wasn't complete. Other surface effects were not identify.

Organoleptic examination was found that this material have excellent elasticity and plasticity in this group of material. Particular elasticity have sample with smallest basis weight of fabric (32 g/m^2). Based on this observations inference that by changing basis weight of fabric and level of impregnation it possible to change elasticity of material.

6. Conclusions

Base on investigation written in this article it could be certify that developed method of aramid silicone laminate manufacturing process allow to produce engineer material with good elasticity and plasticity. This material could be used to produce elastic tubes or other elements characterized with high strength and elasticity. In addition this material could be used like modern biomedical material characterized with good strength properties, plasticity, human tissue interlayer and high bio-compatibility.

Next advantage these materials is diversified surface roughness. Obtained very smooth surface facilitate easy glide also from the other side obtained surface roughness facilitate stabilization in specified environment.

Outstanding topic is the manufacturing technological process to produce material without surface defects like pores, holes and solvent rests.

Dispose of these two problems determines possible medical application of this composite. Taken under consideration special properties and probability of usage this biomaterial in medicine like good bio-compatible with human body environment. Aramid silicone laminate could be attractive alternative for composite material used in medical and others purposes.

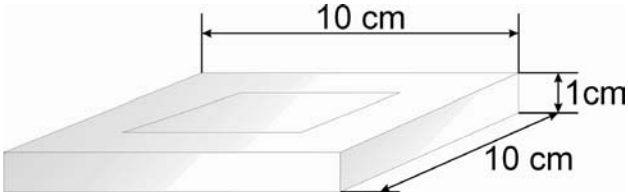

Fig. 8. The demonstrative patern of the stand for samples

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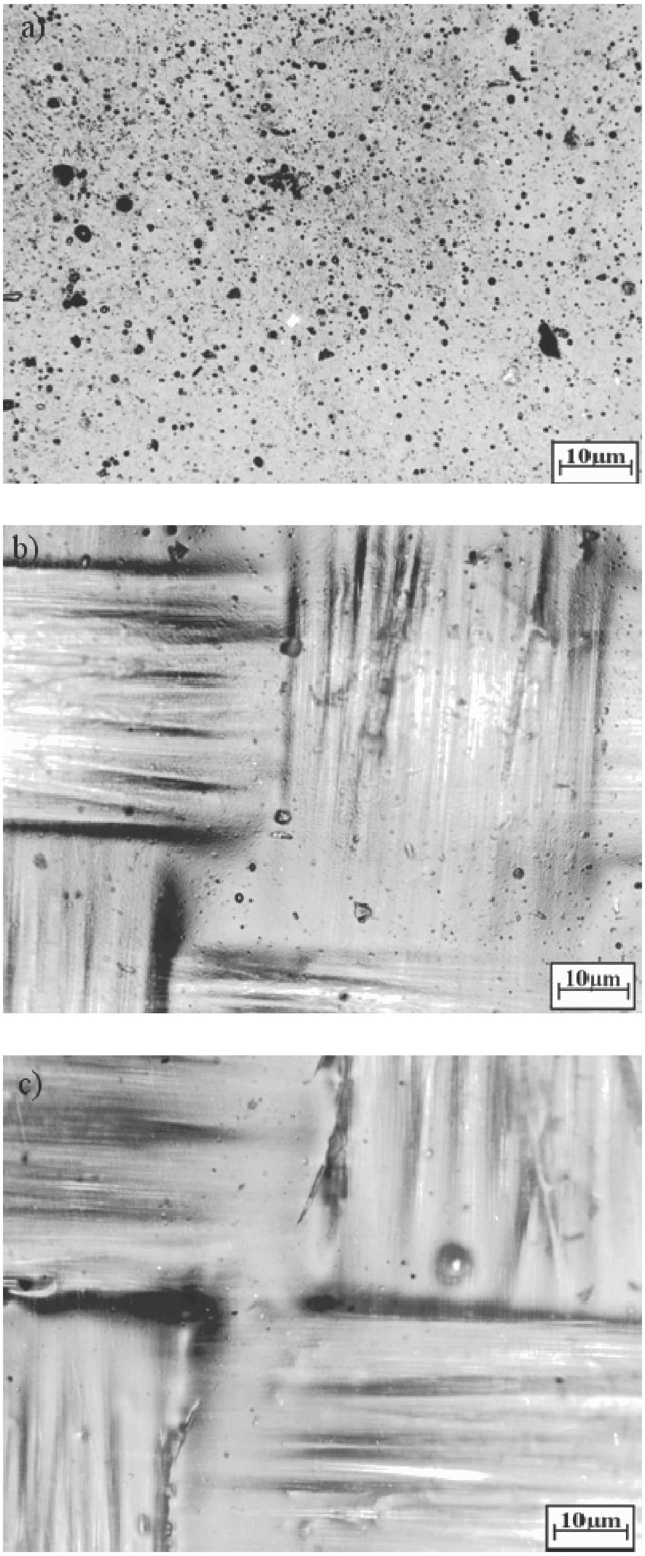

Fig. 9. Top surface of samples made base on aramid fabric with basis weight a) 36 g/m^2; b) 61 g/m^2; c) 173 g/m^2

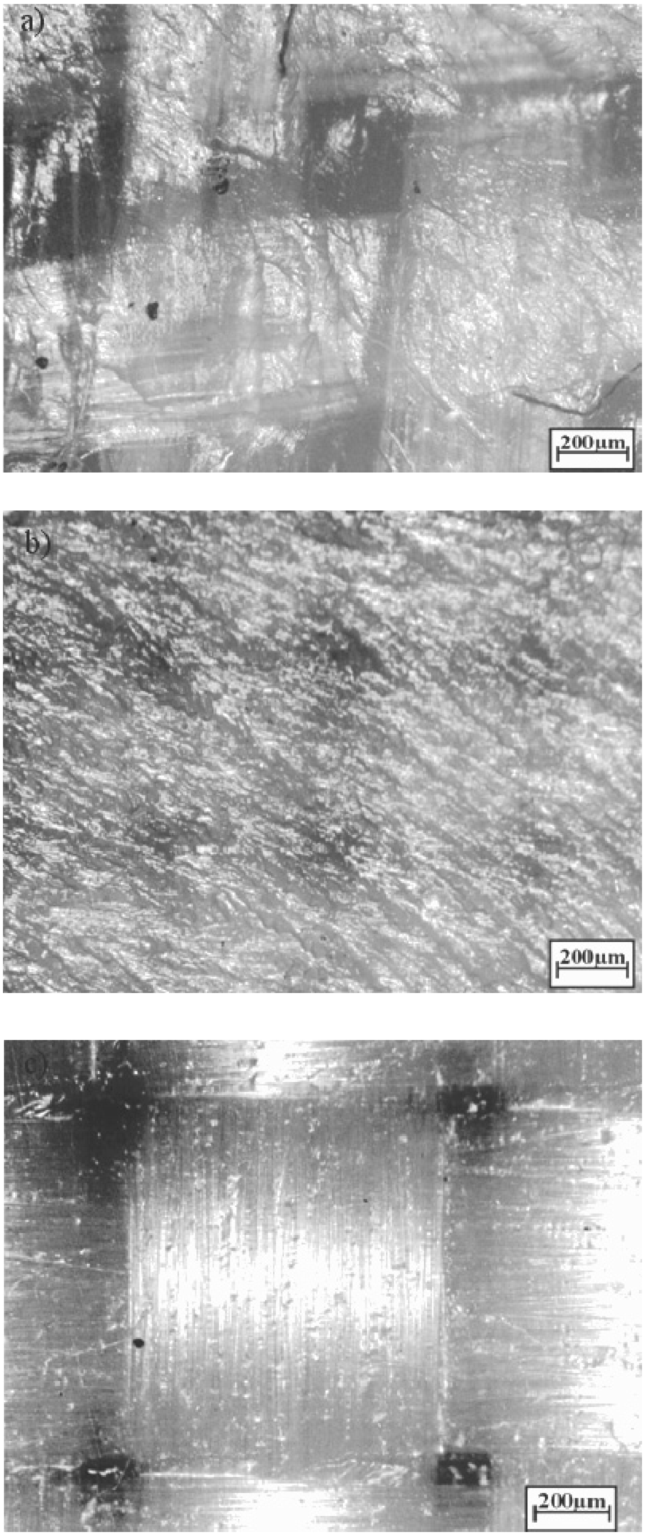

Fig. 10. Contact with base bottom surface of samples made base on aramid fabric with basis weight a) 36 g/m^2; b) 61 g/m^2; c) 173 g/m^2

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