Nonwovens From Usher / Ester Fibers

By:
Dr: Hashim Ali Salem & Mohamed Ahmed I. Algalib

Key words : binder , cellulose , Easter , peak , Nonwovens , web

Abstract:

This research has been executed at the Sudan University of Science and Technology to produce and evaluate nonwoven fabrics manufactured from usher - Ester fibers. This type of nonwoven fabric is produced by a thermal bonding process. From such composition, the resulting products are investigated. The results have shown that, by appropriately selecting the combination of fibers and process condition, excellent performance properties could be obtained. Ester unicomponent fiber and an Easter Bio (Gp copolyester bicomponent (Ester /pp)) fiber were selected as binder fibers to make thermal calendered nonwoven products. Another advantage of these binder fibers is their relatively low melting temperature (100-110°C).

The effect of some key processing variables, such as blending ratio and bonding temperature on peak loads were studied. Preparation, structure and properties of Usher Ester nonwoven fabrics as well are discussed.

ملخـــــــــــص :

تم هذا البحث بجامعة السودان للعلوم والتكنولوجيا لانتاج اقمشة غير منسوجة من شعيرات الايستر والعشر تستخدم في إمتصاص السوائل وقد استخدم نظام الترابط الحرارى . وقد أثبتت النتائج أن نسبة الخلط واختلاف طرق الأنتاج يمكن أن يؤدي الي انتاج منتج يحقق الغرض النهائى . استخدمت شعيرات الايستر كرابط حراري وذلك لصغر درجة انصهارها (100 درجة مئوية). تمت دراسة اثر بعض المتغيرات مثل نسبة الخلط ودرجة الربط الحراري علي الاحمال العظمي للقماش.

1-Introduction:

The production of nonwoven fabrics can be made through continuous processes. Using fibers as input materials, the output obtained is a fabric in a roll form. Nonwoven fabrics are usually constructed by three basic methods (mechanical, chemical and thermal bonding) [1]. Nonwoven fabrics made of usher fibers would be made in this work to be formed by using one of the following methods:-

a) Thermal bonding.
b) Stitch bonding.
c) Thermal with boding thread.
d) Laminated fabrics.

The basic fibrous layers that to be reinforced mechanically or chemically, are formed mostly of planary fibrous products called carded webs, sandwich webs and isotropic webs [7].

The common features of all these fibrous systems are:

a- Fibres arrangement.
b- Surface uniformity.
c- Fibres orientation.

The formation of the web may be done basically in either of the following Ways:-

a- mechanically
b- aerodynamically
c- hydrodinamically
d- by an electrostatic field

The arrangement of the fiber web may be:

a- longitudinal
b- crosswise
c- longitudinal and crosswise
d- randomly arranged

The fiber web is affected by:-

a- The properties of the fibers

b- The amount of fibers in a surface or volume unit

c- The arrangement of the fibers

2- Materials & Methods:

The usher fibres used in this experiment were collected from different areas of Sudan. The Usher fibres used in this work were scoured and bleached and having a moisture content of 3.2%, a micronaire value of 6.4%, and a mean fiber length of 26mm. The bicomponent (Ester /pp) staple fibers used in this study were produced by Eastman Chemical Company.

The processing steps are shown in Figure (1). Firstly, the fibres were opened by hand and then weighed according to the desired blend ratio and fabric weight. The blended fibers were then carded to form a web using a modified Hollingsworth card. The resulting carded fabric weights varied from 20 grams/m² to 60 grams/m². The carded webs were then thermally point-bonded using a Ramisch kleinewefers calendered with a bonded area of 16.6%. Three blend ratios (85/15, 70/30 and 50/50 usher/Binder fibers) are used with three calendering temperatures (100°C, 110°C and 120°C,).Two nip pressures (0.33MPa, and 0.4MPa) were used . All the webs were calendered at the same speed of 10m/min.

The effect of some key processing variables, such as blend ratio and bonding temperatures on peak loads were studied.

Figure (1): Flow chart of processing procedures

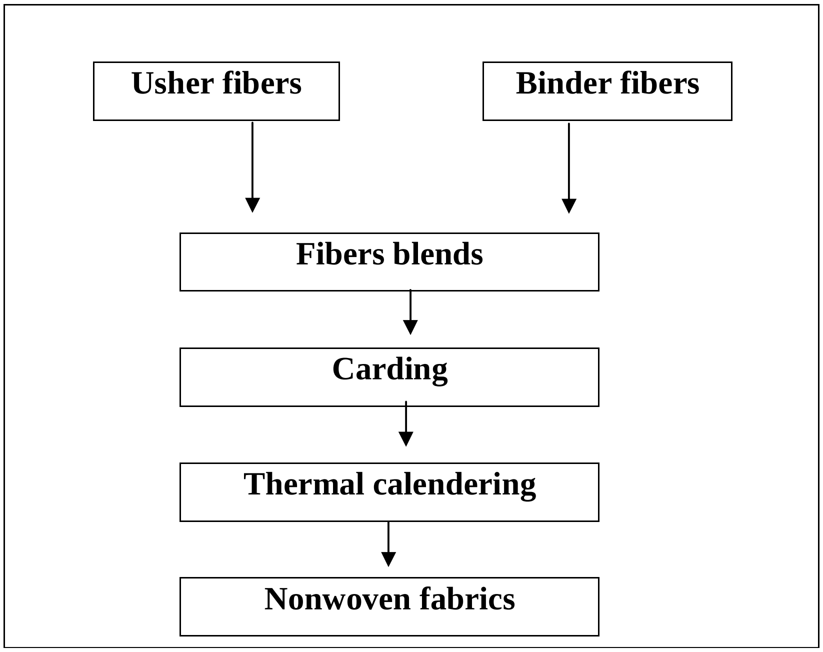
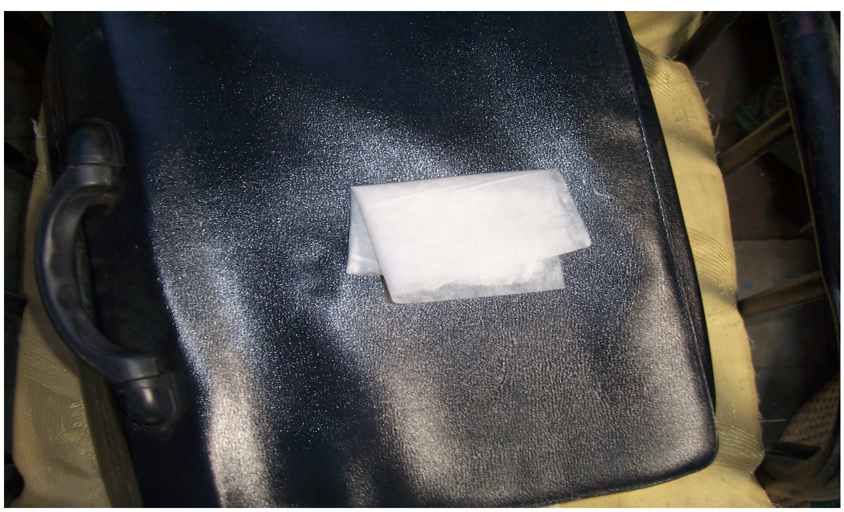


Figure (2): nonwoven fabric made of usher - Ester fibers (85%E 15%U)



The tensile properties of nonwoven fabrics were tested according to ASTM D 1117-80 standard test methods[4]. All the tensile tests were carried out under the standard atmospheric conditions for testing textiles (the temperature of 21±1°C and the relative humidity of 65 ± 2%).The thermal analysis of the binder fiber was performed using the Mettler DSC25 machine at scanning rate of 10°C/min.

The weight of nonwoven fabrics was determined according to INDA standard Test 130.1-92 Method for the mass per unit Area of Nonwoven fabrics.

Scanning Electron Microscopy (SEM) images were taken for bonded points and the failure structure was indicated under a Hitachi S- 3500 N Scanning Electron Microscope. An electronic beam of 20.0 KV vacuumed at 50MPa was used. A magnification of 80 was used for these images.

3- Results and Discussion:-

3-1 Fiber properties:-

The Physical properties of the fibers used in this research are listed on Table (1). The data show that the tenacity or peak strength of Ester unicomponent fiber is nearly the same as that of usher fiber. While the tenacity or peak strength of Ester bicomponent (Ester /PP) fiber is much greater than that of usher fiber. The peak extension of both Ester unicomponent and bicomponent fibers is much greater than that of the usher fibers [2].

The melting point temperature of the Usher fiber is around 110°C. This is much lower than that of the cellulose acetate fiber (which is around 250°C).

This low melting point gives this fiber the chance to be used as a binder fiber [5]

Table (1) : Properties of selected fibers (single filament)

	Usher	Ester	Ester /PP
Filament density g/cm³	.787	1.2	1.1
Filament tex (tex)	0.19	0.44	0.44
Peak extension (%)	3.6	144.0	96.0
Peak strength(Mn/tex)	132.1	138.0	269.6
Initial modulus (Mn/tex)	232.7	204.6	392.5
Staple length(inches)	1.05	1.0	1.5
Crimps (/inch)	-	Not measurable	11

3-2 Fabric properties:

The produced nonwoven fabric has a weight of 18 grams per square meter, while the tensile strength is 124N/m. The peak load increases with the increase of the Ester binder component. The piece of nonwoven fabric is shown in Figure (2) while the results are shown on Table (2).This causes the increase in the number of bond points and the effective bond area. However, at a higher bonding temperature (120˚c) and higher Ester binder fiber component (Ester component above30%), the peak load decreases with the increase in Ester binder fiber. This may be caused by the various failure mechanisms of the fabrics bonded at higher temperatures [8].

Table (2) : Test results of nonwoven fabric (U/E)

Property	Value
Weight (g/m^2)	18
Thickness (mm)	0.12
Tensile strength (n/m)	124
Breaking elongation (%)	28
Liquid strike through(sec/5ml)	6.2

3.3-Effect of bonding temperature on peak load of usher/ Ester Nonwoven fabric:

The Effect of bonding temperature on fabric peak load along the machine direction is shown in Figure 3. With the increase in the calendering temperature, the peak load increases at lower binder fiber component (< 30%). The observed increase in the strength of the fabrics is due to the formation of better-developed bonding structure. The regular shape of bond point and smooth surface of the fabrics bonded at high bonding temperatures show the well-developed bond structure. Again, the decrease of peak load at higher binder fiber component and higher bonding temperatures is due to the various failure mechanisms of the nonwoven fabrics. The decrease in peak load at higher bonding temperatures was attributed to the loss of fiber integrity and the formation of film-like spots at high temperatures as well as the reduction in the load transferred from fibre to fibre via bonding points[6].

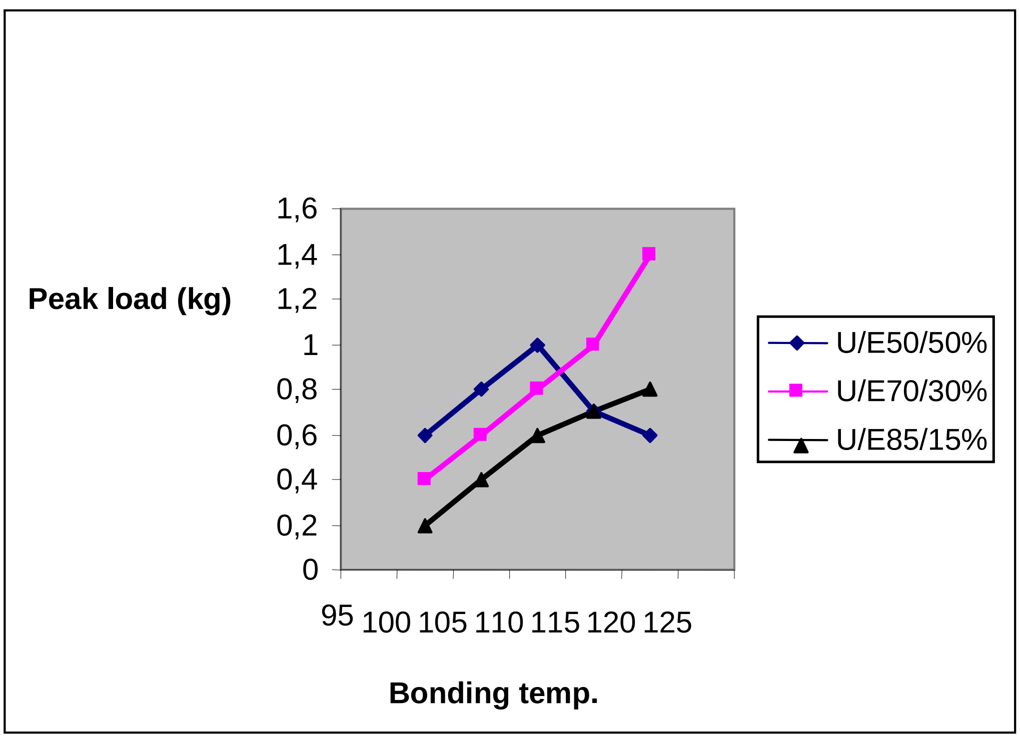


Fig. (3) : effect of bonding temperature on peak load

The well distribution due to the high elasticity of the fiber (high peak extension and low modulus), leads to low tensile properties of the final nonwoven fabrics. So a bicomponent fiber, Ester with Ester Bio, GP copolyester as the sheath, and polypropylene as the stiffer core was selected as the binder fiber instead of Ester unicomponent fiber(3).

Figures (4 & 5) show that at the two blend ratios usher/binder fiber of (15/85) and (30/70) at the three bonding temperatures (100, 110,120) c° , the peak loads of usher/ (Ester /pp) nonwoven fabrics are much higher than that of usher/ Ester nonwoven. Therefore, using Ester / pp bicomponent fiber as a binder fiber can improve the tensile properties of (Usher/ Ester) nonwoven Fabrics. This improvement in tensile properties is the result of better binder properties as well as improved processing characteristics of the modified binder fiber.

Usher / Ester =15/85

Calendering Pressure =0.33 ~ 0.4 MPa

Calendering speed =10m /min

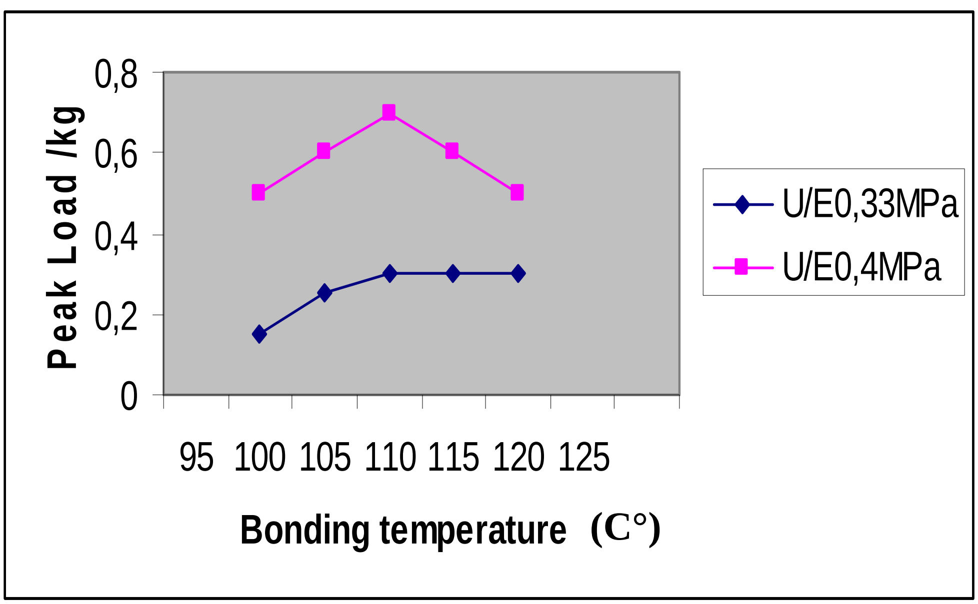


Fig. (4): Relations between Bonding temperature and peak loads for 15/85 Usher/ ESTER

Usher / Ester =30/70

Calendering Pressure =0.33 ~ 0.4 MPa

Calendering speed =10m /min

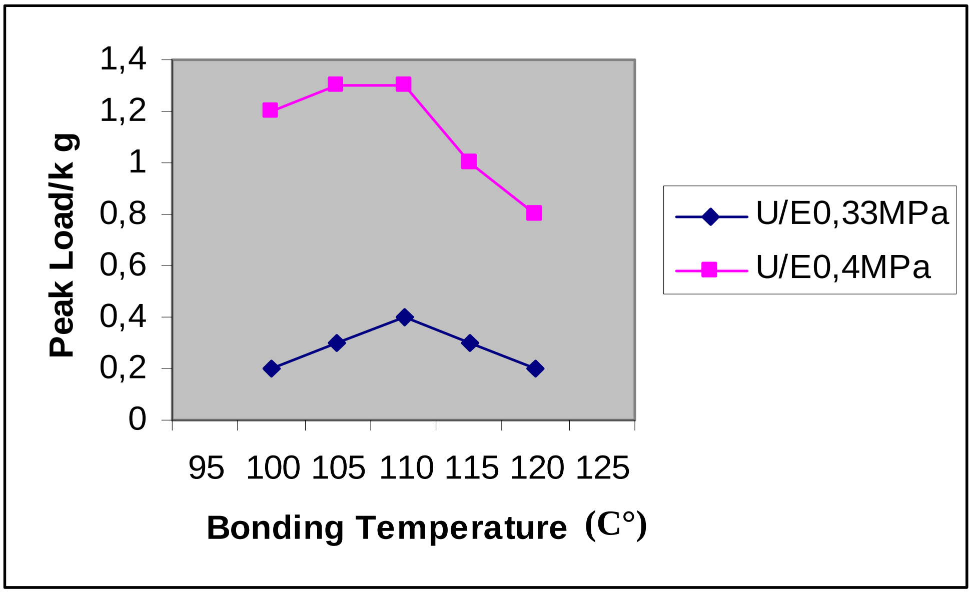


Fig. (5): Relations between Bonding temperature and peak loads for 30/70 Usher/ ESTER

Failure of nonwoven fabrics can occur due to the failure of the fiber (fiber breakage) or failure within the bond (bond breakage or cohesive failure) at the fiber-binder bonding interface, or by a combination of these modes. Structure and fabric deformation mechanisms can lead to a variety of unique failure mechanisms for nonwoven fabrics [(5)]. The nonwoven fabric failure mechanisms are influenced by the fiber physical properties such as adhesive properties, structural properties (including the relative frequency and structure of the bonding elements), fiber orientation and the degree of liberty of movement of the fibers between the bond points. Physical properties of the nonwovens would be controlled by the first failure occurring in the fabric sample. Based on this assumption it could be said that the failure mechanism of nonwoven fabrics of high Ester binder fiber component bonded at a higher temperature, is different from that of the nonwoven fabrics bonded at a low calendering temperature. This difference in failure mechanism is clear via images (not shown) obtained by this work for the failed structures of the fabrics produced with different binder fiber compositions.

These observations are consistent with the study of the failure mechanism of thermal point-bonding temperature .At low binder fiber component and low bonding temperatures, the bond failure mechanism was found to be due to the loss of interfacial adhesion at the bond site leading to bond disintegration. At high binder fiber component and high bonding temperatures, the failure mechanism was due to the cohesive failure of the fibers near the bond periphery[7].

4-Conclusion:

Nonwoven fabrics produced from Usher / Ester fibres could be used in various areas because the fiber has special properties that make it a suitable raw material for many products. Based on the above, high strong Usher/ (Ester/pp) nonwoven fabrics can be produced by using usher (Ester/pp) at a blend ratio of 50/50 and a thermal calendering temperature at 110C$^{\circ}$ under a pressure of 0.33MPa. In fact the tensile properties of usher/ (Ester/pp) nonwoven fabrics were found to be comparable to, or better than that of Usher/Cellulose Acetate nonwovens. This work succeeded to produce non woven fabrics of high quality performance from Usher fibre blended with other fibres. The effects of blending ratios and bonding temperatures on the tensile strength of the produced non woven fabrics were examined and discussed closely. It has to be said here that this research should lead to invest the huge amount of Usher fibres in Sudan so as to be transferred into non woven fabrics.

5-References:-

1. Rasko, K.W. (1990). Manual of nonwovens, Atlanta. U.S.A.
2. Identification of Textile materials (1975). Seven Editions the textile Institute – Manchester. U.K.
3. Booth, J.E.(1970) Principles of Textile Testing, third Editions, London, U.K.
4. Hearle, J.S; Morton, W.E (1970). Physical Properties of textile fibers.
   J .Sc. Tech. Vol. 23 No 4: 20-23.
5. Bonhoeft, J.W (1990). The Development of Nonwovens fabric and Products that are Friendly to the Environment. Nonwovens conference.
6. Larson, G, B (1997). Biodegradable Staple Nonwovens fabrics. Ph.D thesis, Calendared with the Assistance of an Aqueous Solvent. University of Tennessee. U.S.A.
7. http://www.husqvarnastudio.co.uk/products/johnsolomon/nonwoven.htm
8. http://www.engr.utk.edu/mse/pages/Textile/Thermal%20Bonding.htm