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CORRELATION BETWEEN SURFACE CHARACTERISTICS AND HONEYDEW STICKINESS

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Abstract

This study is based essentially on adhesion between polymer and metallic industrial surface and artificial honeydew. This measurement of adhesion will be carried out with a pegosity (tack) test. Actually, the objective of this study is to find experimentally the influence of various parameters like composition, nature and water content of honeydews. The aim of this work is to highlight the importance of surface treatment on adhesion energy. In the first part, a fine characterization has been carried out on industrial surfaces and artificial honeydews. This study has shown the heterogeneity of the surfaces as far topographical and chemical aspects are concerned. In the second part, the measurement of adhesion has been carried out on substrates and honeydews with the help of a pegosity (tack) test using two types of geometry. The results indicate clearly, that taking into account the composition of honeydews, the nature of the surfaces plays an important role in adhesion energy.

Introduction

Cotton stickiness problems result from an excessive quantity of sugar on the cotton fibre generated by plants or insects. This phenomenon is a source of serious problems for farmers, cotton industries and particularly spinners. The pegosity represents a borderline case of adhesion. Proprieties of materials (surface energy, viscous elasticity, surface structure) and the contact conditions (time, pressure, contact area) are the main parameters, which have to be taken into account in an adhesion study.

In the first place, industrials surfaces consist in polymer and stainless steel have been characterise. The following parameters have been measured:

- Surface energy by thermodynamic characterisation by wetting
- Topography characterisation by Atomic Force Microscopy (AFM) and Scanning Electronic Microscopy (SEM),
- Chemical composition by Infrared Spectroscopy

Then, the adhesion between artificial honeydews and industrials surfaces has to be studied by a pegosity test.

Materials and Methods

Many polymer surfaces (EPDM, NBR, HNBR, and mosaic) have been characterised by different techniques:

Thermodynamic characterisation

Before any test, these surfaces have been carefully cleaned. The aim of this test is to determine the contact angle between a liquid and a solid surface in order to calculate the surface energy. These contact angles [FOWKES-64] were very sensitive to surface properties, to roughness, and to chain mobility [FOWKES-93].

Topography characterisation by AFM and SEM

The principle of AFM is to measure different interaction forces between ideally atomic point fixed in the extremity arms of lever and atoms of surface of material. Thanks to this technique, a fine characterisation of the structure can be obtained.

Chemical composition by Infrared spectroscopy

Fourier Infrared Spectroscopy is based on adsorption of infrared radiation by the analysed material.

After characterisation of industrial surfaces, with different techniques, it is interesting to proceed to a pegosity test in order to determine the adhesion energy between surfaces and artificial honeydews.

Results and discussion

Results of surfaces characterisation by wetting

In this test, an apolar liquid (diiodomethane CH_2I_2) and a polar liquid water have been used. An average of twenty measurements have been carried out using a 5µl drop.

Table 1. Values of contact angle and surfaces energies

Manufacturer	Nomenclature	θ (H_2O)	θ CH_2I_2)	gsd(mJ/m^2)	gsp(mJ/m^2)	gs(mJ/m^2)
A	Links1	90	46	38	1	39
	Links2	65	48	37	10	47
	PMMA	54	34	44	14	58
	Stainless steel	60	47	36	14	50
B	Rubber red	88	74	21	5	27
	Rubber blue	74	39	42	5	47
C	ER60	110	68	25	2	27
	ER80	110	74	21	1	22
	TER90	103	66	26	0	26
	EE50	97	50	36	0	36
	HB55	95	41	41	0	41
	HX5040	96	45	38	1	39
	CZBN10	101	48	37	1	38

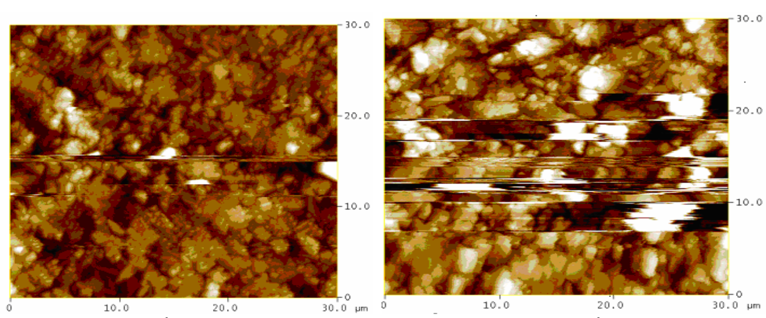
Table 1 indicates a large variability of contact angles. It can be noticed that these surfaces were more hydrophobic than hydrophilic. The PMMA and stainless steel surfaces can be considered as more hydrophilic. The same conclusion can be drawn for links 1 and links 2.

The mosaic surfaces have shown a wide wetting values dispersion. These results highlight a wide chemical and /or topographical heterogeneity.

AFM results

AFM tests have been carried out to determine the surface roughness, but the result is no very accurate because of a viscous elasticity of surfaces.

For mosaic surfaces we noticed the presence of little domains with different sizes as shown in Figure 1 (Scanned surface 30x30mm).



Mosaic B **Mosaic D**

Figure 1 : Mosaic AFM pictures

Figure 1. Mosaic AFM results

SEM results

The surface morphology has been examined by SEM at different magnitudes. For ER60 and ER80 surface, respectively of 100µm and 50µm scale, Figure 2, we noticed the presence of amalgam on the surface. ER60 is less rough than ER80.

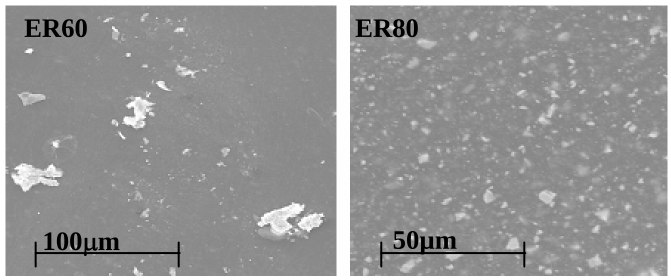


Figure 2. ER rubbers SEM results

For TER90 and EE50 surfaces (Figure 3) there are also small particles on the surface (confirmed by10µm scale). The particulates existing on CZBN10 surface were less visible on the HB55 surface.

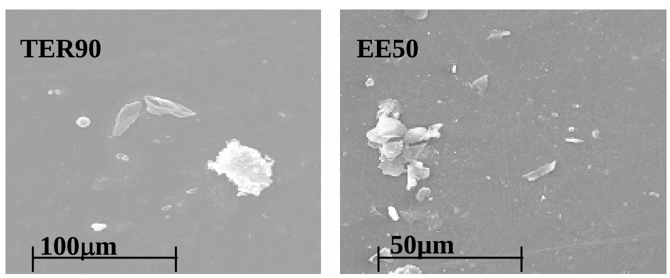


Figure 3. TER and EE rubbers SEM results

The roughness of mosaic surface is very clearly visible on SEM pictures (Figure 4) at a scale of 10µm. The specks existing on D mosaic surface were more important than on B mosaic. This explains the dispersion of wetting test results.

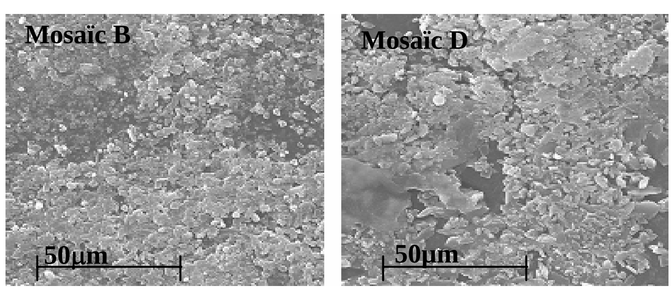


Figure 4. Mosaic rubbers SEM results

SEM Conclusion

All SEM observations enable to conclude that the superficial layers of different surfaces were not the same and have been submit to different treatments, which can influence the interaction between surfaces and honeydews.

Infrared Spectroscopy Results T

This measurements highlights the following points:

- The chemical composition of mosaic surfaces was nearly the same.
- The chemical composition of HNBR surface was very different. But, this difference was not obvious in the wetting values.
- Same comments for EPDM surfaces (ER60 and ER80).

Pegosity Test Results

In this part, results of adhesion between surfaces and drop of honeydews have been discussed. the method used for this test was tack test with flat probe (Figure 5).

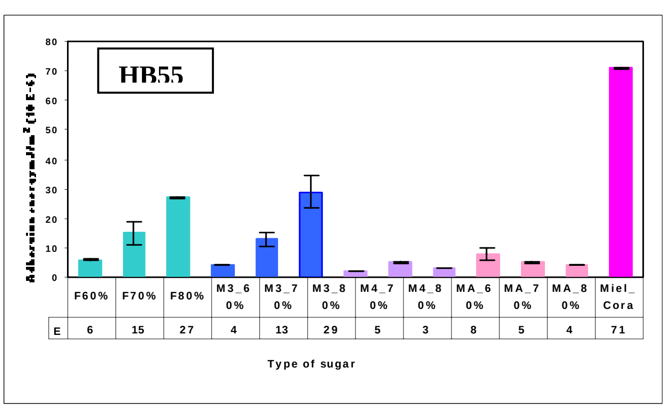
Figure 5. Flat probe

The force apply in this test was of 10N, with a descent speed is 5mm/min, and ascend speed is 10mm/min. These parameters have been used for all artificial honeydews M4 and MA (Table 2).

The comment for mosaic surface is the tests. Values indicated were an average of ten different tests.

Table 2. Tested artificial honeydews

Simple sugars	F: fructose, G: glucose, S: sacharose
Complex sugars	Composition
M_1	½ F + ½ G
M_{2-1}	1/3 F + 1/3 G + 1/3 S
M_{2-2}	1/4 F + 1/4 G + 1/2 S
M_3	25%F + 20%G + 39%S + 16%M
M_4	25%F+ 20%G + 37%S + 16%M + 2%T
M_A	20%F+ 20%G + 18%S + 40%M + 2%T
M_B	12,5%F+ 12,5%G + 18%S + 16%M + 40% T + 1% Tu



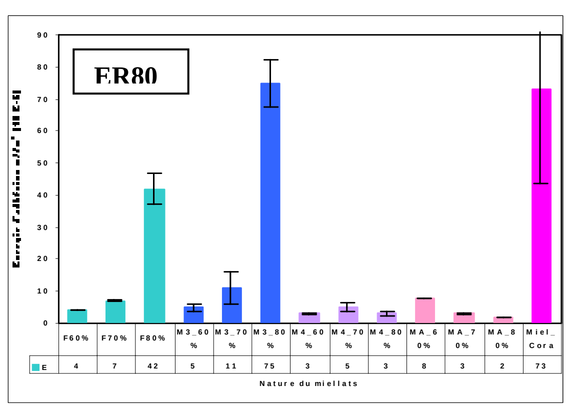


Figure 6. Adhesion energy vs. Type of sugar as a function of water content for HB55 and ER80

Figure 6 shows a logic evolution for adhesion energy as a function of water content of artificial honeydew. The surface energy increase when the water content decreases. The same comment can be drawn for ER80 surface. But, the unconventional behaviour of sugar with trehalulose has to be highlighted. Such a behaviour is also shown on Figure 7.

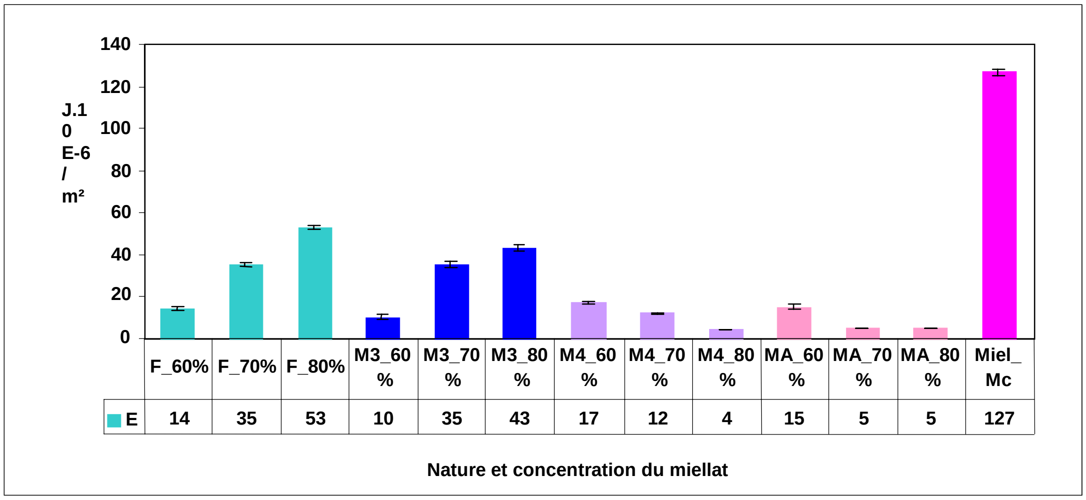


Figure 7. Adhesion energy vs. Type of sugar as a function of water content for Mosaic D.
Adhesion energy J 10-6/m2

Conclusion

The aim of this study was to identify the influence of surface characteristics consist in polymers and stainless steel to adhesion energy of honeydew with different composition and water content. After a fine characterisation of materials, our study was essentially based on adhesion energy measurements for different type of surfaces and with different treatments. This test has shown that the composition and the water content of honeydews and the nature of the surfaces play a major role in this domain. Probably, from these results, a surface treatment able to reduce stickiness could be studied.

Bibliography

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