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Analysis of the asphaltic binder by Atomic Force Microscopy (AFM)

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Abstract – In this work asphaltic binder surfaces were analyzed by Atomic Force Microscopy (AFM). Measurements in intermittent contact mode and contact mode were realized to study changes of the topography, phase contrast and elastic response of the asphaltic binder. Force-distance curves were used to assess adhesion, adesion work and modulus of elasticity.

Asphalt binder was early described as a colloidal dispersion of asphaltenes micelles in the maltenes[1]. Mesurements of curves force by AFM (Atomic Force Microscopy) were realized in the surface films of asphalt binder. Asphaltic binder CAP 50/70 REPAR was used as the chosen sample. Atomic force microscopy (AFM) images were realized in intermittent contact in order to get information on topography, phase contras. Force-distance curves were performed with the same cantilever. The cantilever for AFM analysis was made NSC -14 from Micromasch. The sensibility of the tip was calibred and constant of the tip used was K = 5 N/m.

Both statistical analysis as well as selected region analysis were accomplished. For the selected analysis different points were chosen in light regions of bees structure randomly [2] in the topography image (fig.1a) to perform the nanoindentations. At the each point different nanoindentation forces were chosen varying from 15nN to 40nN. Samples were imaged before and after indentation and changes in the surface of the binder were qualitatively and quantitatively analyzed as presented in fig.1b. Force-distance curves are represented in figure 2, Curves were analyzed using JPK Image Processing software. Informations obtained were slope, adhesion and work of adhesion. Slope is calculated by linear fit (blue curve), the work adesion is determined by area under force-distance curve (blue curve). The local elastic is calculed by expression S* = SK/K-S. Results are in table 1 shown that values depends of the force and the neighborhood of the regions considered. In order to assess the viscoelastic response of the binder, AFM images were realized every 12 minutes imaging exactly the same area. Results show that this responde depend of the force and region considered.

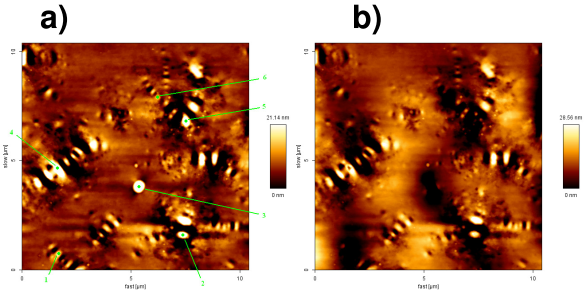

Figure 1: AFM image of the binder asphaltic (CAP 50/70), **a)** before nanoindentations **b)** after nanoindentations.

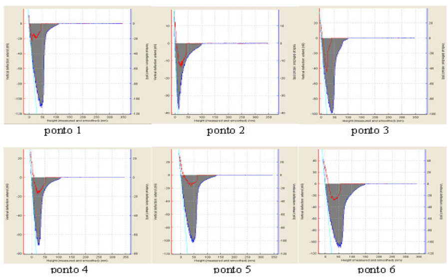

Figure 2: Force-distance curves at each point.

Table 1: Results of the force-distance curves at the each point.

Points - force	Slope (S) (N/m)	Adhesion (nN)	Work of adhesion (10^{-15} J)	Elastic Modulus (S*) (N/m)
1 (10nN)	4.171	89.47	14.16	25.157
2 (15nN)	2.620	30.26	1.833	5.504
3 (20nN)	2.622	40.95	2.734	5.513
4 (25nN)	2.955	51.10	4.833	7.224
5 (30nN)	2.907	36.04	2.532	6.944
6 (40nN)	2.818	42.31	3.513	6.457

References

[1] Bardon C, Barré L, Espinat D, Guille V, Li MH, Lambard J, et al. The colloidal structure of crude oils and suspensions of asphaltenes and resins. Fuel Sci TechnolInt 1996;14:203–42.

[2] Identification of Microstructural Components of Bitumen by Means of Atomic Force Microscopy (AFM) PAMM · Proc. Appl. Math. Mech. 4, 400–401 (2004).