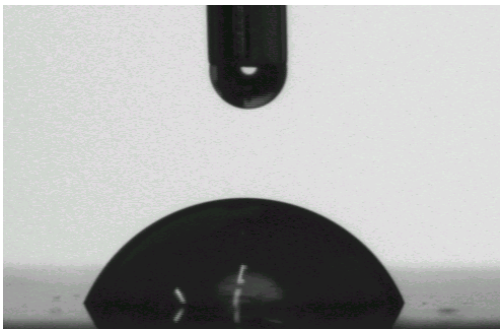
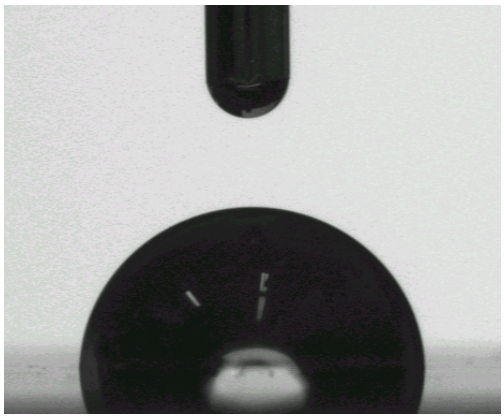
Surface Free Energy of ABS plastic

Contact angle describes the shape of a drop of liquid in contact with a solid. The drop will spread out until the liquid's cohesion is balanced by its adhesion to the solid. If the contact angle is smaller than 90 degrees, liquid wets the surface. If the contact angle is larger than 90 degrees, liquid does not wet the surface. Wetting can be spreading, immersional or adhesional. Surface energy of the solid material can be calculated if the contact angles are measured using at least three different liquids with known properties.

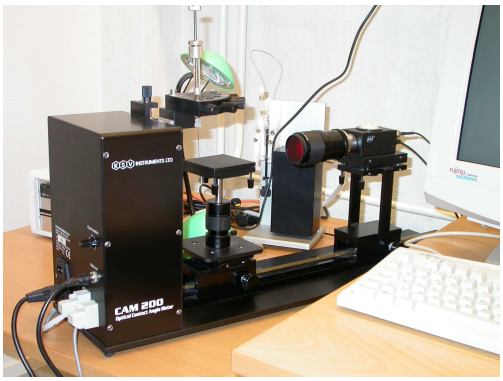




Typically plastics have low surface energies and need an efficient pretreatment to obtain good adhesion. Surface energies of plastics are generally 30 – 45 mJ / m^2. ABS (Acrylonitrile butadiene styrene) is a widely used polymer in plastic industry. In this study, surface energy of ABS plastic was determined after washing. ABS plastic was washed with (1) deionized water, (2) nonionic tensides and butylglycol based detergent, (3) hydrocarbon mixture containing detergent and (4) hydrogen peroxide. ABS 'as delivered' was measured as a reference.

Surface energy of ABS plastic

Small drops of liquid were placed on the sample surface. The contact angle between the liquid and the sample surface was measured as a function of time. Deionized water, methylene iodide and ethylene glycol was used as wetting liquids. Total surface energies and their polar and dispersive components were calculated according to Wu theory. Also acid/base components were calculated according to Liftshitz - van der Waals theory.



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Results

Surface energies of ABS plastic are presented in the table below. The surface energy of the ABS plastic without treatment is 42 mJ/m^2. Pretreatment with deionized water or hydrogen peroxide decrease the surface energy of ABS plastic. Treatment with other washing chemicals (nonionic tenside based detergent or hydrocarbon mixture containing detergent) increase the surface energy. The hydrocarbon containing detergent was not rinsed off after washing. It leaves a film on the surface when dried. The surface of the ABS plastic was electrically charged after the washing with hydrocarbon mixture containing detergent. Nonionic tenside based detergent was rinsed off after cleaning. The surface energy of ABS plastic is higher after cleaning with this rinsed chemical than the surface energy of ABS plastic as delivered.

ABS and washing chemical	**γ^{tot}(Wu)**	γ^{d}(Wu)	γ^{p}(Wu)	γ^{ACID}	γ^{BASE}
as delivered	**42**	35	8	1,0	1,7
deionized water	**38**	34	4	-0,2	2,1
nonionic tenside based detergent	**44**	38	6	0,2	2,1
hydrocarbon mixture	**47**	35	11	0,6	2,8
hydrogen peroxide	**40**	33	7	0,5	2,2

Surface of the ABS plastic as delivered contains more electron accepting sites on the surface than the washed surfaces (i.e. higher acid component, γ^{ACID}). All washed samples contain more electron donating sites (i.e. γ^{BASE}) on the surface than ABS-plastic as such. This method reveals whether the surface is likely to behave as an acid or a base when treated in further process steps. The most polar sample shows also the highest total surface energy.

Conclusions

Good wetting is important for good adhesion. Thus the increased surface energy promotes wetting and adhesion. Contact angle measurement is a suitable method for studying adhesion properties of surfaces. Contact angle measures the outermost surface layer which is directly involved in wetting and adhesion. Differences between the treated ABS-plastic samples are relatively small, within ± 10 %. Depending on detergent the total surface energy of ABS plastic is either increased or decreased after the treatment.

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