Coating of glass

Glass is an inorganic, non-crystalline, chemically robust, transparent solid material with a wide spectrum of uses. Coatings on glasses facilitate to tailor the chemical, mechanical, optical and electrical material properties. The purpose of the applied coating can be functional or decorative or in some cases, both. For example, in optics, the coating of glasses is used to create optical filters; and in case of solar panels the glass coatings are used to generate anti-reflective surfaces that reduce the percentage of light reflected while increasing the output power. The formation of a uniform layer of coating and its explicit durability is dependent on the reliability of the coating process. Hence, it is essential to prepare both the coating material and the glass surface to ensure the successful application coating.

Coating process and surface property measurements

Any unwanted manipulation of surface is termed as contamination. In coating processes, this is detrimental as the contaminating elements constrain the wettability of the surface inhibiting adherence of the coating material to the surface of the glass substrate. Therefore, it becomes essential to clean the glass surfaces prior to the application of coating. The inspection on the cleanliness of a surface can be determined in terms of surface property measurements, example, in case of clean glass surface the contact angle values has been reported to approach zero; and the inhomogeneity in surface composition of the glass substrate can be assessed by means of measuring the surface energy. Also, for effective coating it is required that the surface energy of the cleaned glass substrate surface should essentially be greater than the surface tension of the coating material.

The evaluation of coatings on glass is a critical step prior to the use of the coated glass materials. Primarily, the application of coating can be verified by the changes in contact angle of the coated and uncoated surfaces. The nature of the applied coating can be determined by measuring the corresponding sliding angle. The uniformity of the applied coating can be correlated with the durability of the coated glass, which can be evaluated by ensuring the homogeneity in surface energy and contact angle over the expanse of the coated substrate.

What we offer?

Droplet lab introduces dropometer, a smartphone based optical tensiometer to measure the surface properties of materials. The instrument can measure surface energies and tensions up to 100 mN m^{-1}. Contact angle and sliding angle of 0° - 175° can also be measured. The new tensiometer can be used to critically evaluate and optimize the coating of glass materials for various purposes. The use of the tensiometer involves, but is not limited to the following:

- Measure surface energy of glass substrate
- Determine undesirable substrate surface alterations, if any
- Measure surface tension of the coating material
- Measure contact angle of coating material on glass surface
- Optimize adhesion between coating film and glass surface
- Assess the quality of coating without destroying the coated surface (nondestructive)
- Evaluate the homogeneity of coating on glass
- Determine the nature of coating applied
- Assess the surface properties of coated glass surface

Our Industrial Clients

- Avery Dennison Corporation, Glendale, California
- Teledyne FLIR LLC, Wilsonville, Oregon

Some relevant case studies

1. Cleaning of glass

The preparation of glass substrates forms the first step towards the application of coated glass materials. The efficiency of the coating process depends on reliable adhesion between the coating film and the substrate surface. Therefore, it is critical to use effective options for the cleaning of glass substrate surfaces preceding the application of coating. In this regard, a model study has reported the evaluation of eight chemical treatment methods for cleaning microscopic glass slides for use in silanization[i].

S. No	Chemical Treatment	Mean Contact Angle (°)	Mean Contact Angle after silanization (°)
1.	Mixture of methanol/ hydrochloric acid	<8	53
2.	Mixture of methanol/ hydrochloric acid + incubation in sulphuric acid	<8	60 - 70
3.	Mixture of methanol/ hydrochloric acid + incubation in sulphuric acid + incubation in water at 100 °C	<8	60 - 70
4.	Mixture of ammonium hydroxide/ hydrogen peroxide/ water at 80 °C	<8	60 - 70
5.	Mixture of ammonium hydroxide/ hydrogen peroxide/ water at 80 °C + incubation in hydrochloric acid/ hydrogen peroxide/water mixture	31	60 - 70
6.	Potassium hydroxide (10%) in isopropanol	9	60 - 70
7.	Sodium hydroxide (1 M)	19	32
8.	Sodium hydroxide (1 M) + incubation in hydrogen peroxide/sulphuric acid mixture	12	60 - 70

2. Functional coatings on glass

The chemical robustness and universal availability of glass materials make them choice substrates for a variety of functional coating applications. The large scale applications of such functional coatings depend primarily on the suitability of substrate surface for easy application and mechanical durability. For example, glass substrates with 1H, 1H, 2H, 2H perfluorodecyltriethoxysilane functionalized sol-gel coatings containing different ratios of silica particles were reported for ice phobic application’s[1]. The measurement the contact angle on the coated glass can be used to verify the quality of coating, and / or check if the coat is homogeneous.

Substrate	Functionalization agent (□mol/g)	Silica content in sol (wt. %)	Contact angle (°)	Sliding angle (°)	Surface energy (mJ/m^2)
Glass	-	- -	30.6	- -	61.99
	0.31 - 0.35	5	112.0	- - -	11.69
	-	4	71.3		30.92
	0.31 - 0.35	10	112.9		9.64
	-		82.0		24.33
	0.31 - 0.35	8	121.4	-	6.72
	-	15	99.2	-	11.93
	0.31 - 0.35	12	166.0	1.3	0.85
	-	20	162.7	3.4	1.25
	0.31 - 0.35	16	172.7	0.8	0.24

[1] 10.1016/S0956-5663(99)00043-3

[ii] 10.1021/am504348x