# SPECIMEN FORMAT FOR THESES OF MONTH

| | | |
|---|---|---|
| **Faculty** | **:** | **School of Physical Sciences and Computational Sciences** |
| **Department** | **:** | **PHYSICS** |
| **Branch/ Area:** | **:** | **Thin films** |
| **Sub Subject Heading:** | **:** | **-** |
| **Candidate's Name** | **:** | **AISHWARYA S** |
| **Candidate's Address with email** | **:** | **1A, Palaniappa Thevar street**<br>**Sulur**<br>**Coimbatore**<br>**aish1291@gmail.com** |
| **Title of the thesis** | **:** | **Self cleaning Performance of Polymer-Silane Hydrophobic films** |
| (i) In Roman Script<br>(ii) In roman Script | | **-** |
| **Nomenclature of Degree**: | **:** | **Doctor of Philosophy** |
| **Month & Year of Enrolment**: | **:** | **August 2015** |
| **Month & Year of Registration**: | **:** | **August 2015** |
| **Month &Year of Submission**: | **:** | **September 2019** |
| **Month &Year of Award** | **:** | **October 2020** |
| **Name of Supervisor** | **:** | **Dr. J Shanthi** |
| **Designation of Supervisor** | **:** | **Professor** |
| **Centre/department/school in which research was conducted** | **:** | **Physics/ School of Physical Sciences and Computational Sciences** |
| **University's Name & Address** | **:** | **Avinashilingam Institute for Home-science and Higher Education for Women, Coimbatore** |

**Abstract within 300 words:**

The non-wetting character derived with the lotus-leaf phenomenon of water droplet rolling off from leaf indicates the Hydrophobic/Super-hydrophobic surface, as described by the Wenzel and Cassie–Baxter theories. Even many natural surfaces display Hydrophobic/Superhydrophobic properties. Such properties are characterized by an apparent water contact angle >90°/130° and various adhesions of water on the surface determined by dynamic contact angle measurements. The basic concepts of the hydrophobic surface their properties and applications have been discussed. Synthesis of composite films with hydrophobic properties using Polymers (PVDF, PMMA, PS) and Silanes (TEOS, MTMS, PDMS) of varied molar ratio have been carried out. Low surface energy leads to the less adhesion and high roughness surfaces, making the film effective for hydrophobic surfaces. Characterizations include FTIR analysis, optical property analysis, surface morphology, roughness and thermal analysis. Contact angle measurement was done to ensure the hydrophobicity/ superhydrophobicity of the prepared films. With low surface energy and high surface roughness, hydrophobic property can be obtained. In this study thin films of Polymer-silane composites were prepared by sol-gel and spin coating technique, with the obtained contact angle ranged between 95° to 153° confirming the hydrophobicity. The spectral bands of the composite films have been determined using FTIR spectra. The absence of polar bond proves the hydrophobic nature. These films can also be used as anti-dust coatings as they remove dust easily. And hence has application in window-screens, automobile windows and solar panels. PDMS- Polymer and TEOS/MTMS/PDMS-Polymer films found application as oil-water separator and they are effective in removing the oil spills.

**i) Major objectives** :

The non-wetting character derived with the lotus-leaf phenomenon of water droplet rolling off from leaf indicates the Hydrophobic/Super-hydrophobic surface. Such surfaces have been developed for the past few decades, which made the scientist/researchers to think beyond those surfaces and utilized in various applications. The hydrophobic properties are extremely dependent on the morphology and the topography of surfaces, described by the Wenzel and Cassie–Baxter theories. Hydrophobicity arises when a molecule does not partake in the hydrogen bonding of water. When a hydrophobic particle is submerged in water, a volume created as the density of water vanishes. The water droplet is suspended on a composite interface made of solid and air trapped between the droplet and the surface. Cassie-Baxter equation can predict superhydrophobic properties and sliding angle, α, due to the solid-vapour interface. These surfaces have remarkable self-cleaning and anti-adhesive properties. Materials with superhydrophobic or superoleophobic properties are in extreme demand due to numerous potential applications such as in anti-corrosion coatings, anti-icing coatings, liquid-repellent textiles, oil/water separation, nanoparticles assembly, microfluidic devices, printing techniques, optical devices and high-sensitive sensors. In many of these applications, the presence of an air layer trapped inside the surface roughness can reduce the liquid penetration (oil/water separation, anti-fogging), the ion penetration (anti-corrosion, water desalination, batteries), the heat transfer (anti-icing), while the surface roughness can improve the intrinsic properties of the materials (optical, electrical, catalytic properties).

Wettability is the tendency of the fluid to spread on or to adhere to a solid surface. It is the interaction between fluid and solid phases. It describes the ability of a fluid phase to preferentially wet a solid surface in the presence of a second immiscible phase. A drop of preferentially wetting fluid will displace another fluid; at the extreme it will spread over the entire surface.

Conversely, if a non-wetting fluid is dropped onto a surface already covered by the wetting fluid, it will bead up, minimizing its contact angle with the solid. If the condition is neither strongly water wetting nor strongly oil wetting, the balance of forces in the oil/water/solid system will result in a contact angle θ, between the fluids at the solid surface. The balance forces, controls wettability between the solid and the fluids and the interfacial tension between the fluids. Surface tension results from the natural tendency of molecules at a fluid interface to be at a higher energy state than those in the bulk of a fluid.

The non-wetting character was derived with the lotus-leaf phenomenon of water droplet rolling off from leaf. With various leaves, natural organisms behaving under such criteria have been identified and reviewed. This paved way for theories such as Cassie-Baxter, Wenzel etc., which were used mathematically.

The apparent water contact angle of smooth surfaces were described by the Young equation, it depends on the solid–vapour, solid– liquid and liquid–vapour surface tensions and does not exceed 125° to 130°, whatever be the surface chemistry. Even many natural surfaces display Hydrophobic/Superhydrophobic properties. Such properties are characterized by an apparent water contact angle >90°/130° and various adhesions of water on the surface determined by dynamic contact angle measurements. Intensive surface analyses at a micro and nano- scale have shown the necessity of surface structures. The hydrophobic properties are extremely dependent on the morphology and the topography of surfaces, described by the Wenzel and Cassie–Baxter equations . Indeed, in the Wenzel state ($\cos \theta = r \cos \theta_Y$), the water droplet is in full contact with the surface and $\theta_Y$ is amplified by a roughness parameter (r). Superhydrophobic properties can be reached only if $\theta_Y > 90°$ (intrinsically hydrophobic materials).

**ii) Hypothesis**:

In the present research work, the basic concepts of the hydrophobic surfaces, their properties and applications have been discussed. Synthesis of composite films with hydrophobic properties using Polymers (PVDF, PMMA, PS) and Silanes (TEOS, MTMS, PDMS) of varied molar ratio have been carried out. Low surface energy leads to the less adhesion and high roughness surfaces, making the film effective for hydrophobic surfaces. Such surfaces has wide applications in the field of self-cleaning coatings, oil-water separator, anti-icing and anti-fogging coatings.

**iii) Methodology** :

Hydrophobic thin films have been developed with Polymer- Silane composites. Seven sets of solutions were prepared with PVDF, PMMA, PS, TEOS, MTMS and PDMS with the help of Ultra-sonication. The composite sets were given below,

Set - I [Polymer + TEOS]

Set – II [Polymer + MTMS]

Set – III [Polymer + PDMS]

Set – IV [Polymer + TEOS + MTMS]

Set – V [Polymer + TEOS + PDMS]

Set – VI [Polymer + MTMS + PDMS]

Set – VII [Polymer + TEOS + MTMS + PDMS]

The sols were aged for different time duration to get consistent solution. The glass substrates were cleaned with HCl, $HNO_3$, distilled water and dried in Hot-Air oven for two hours at 60°C.

The cleaned substrates were coated with the prepared sols by Sol-gel and Spin-coating technique. The coated films were annealed at their respective temperatures with ramping rate of 1°C/min. The functional groups have been elucidated with FTIR spectroscopy (FT/IR-4700TypeA) . The surface morphology and chemical analyzes were analyzed by Field Emission Scanning Electron

Microscope (FE-SEM) and Energy Dispersive X-ray (EDX) , in which the image is produced by the signals due to the interaction of the electron beam with the atoms within the sample. The hydrophobicity is measured with the contact angle meter (Holmarc Inc.,). Surface Roughness and Surface energy has a great impact in 5

developing hydrophobic films. Surface roughness was determined with 3D Zeta profilometry. The surface energy values were computed with Hamaker's constant. Using UV-Visible spectroscopy , the optical properties have been derived. The thermal stability of the films were explained with the TG-DTA results.

## iv) Findings:

- In this study thin films of Polymer-silane composites were prepared by sol-gel and spin coating technique, and the obtained contact angle ranged between 95° to 153°.This confirms the hydrophobicity.

- The spectral bands of the composite films have been determined using FTIR spectra. The absence of polar bond proves the hydrophobic nature.

- These films can also be used as anti-dust coatings as they remove dust easily. And hence has application in window-screens, automobile windows and solar panels. PDMS- Polymer films found application as oil-water separator and they are effective in removing the oil spills.

**Examiners**

**Internal Examiner :**

Dr. O. Mahammad Hussain

Physics Department

Sri Venkateswara University , Tirupati – 517502

Andhra Pradesh