A REVIEW ON SYNTHESIS AND DEVELOPMENT OF SUPERHYDROPHOBIC COATING

Ajmal Ubaid[1], **Manu Harilal**[2]

[1]*Ajmal Ubaid, Department of Metallurgical and Materials Engineering, Amal Jyothi College of Engineering, Kerala, India*
[2]*Manu Harilal, Assistant Professor, Dept. of Metallurgical and Materials Engineering, Amal Jyothi College of Engineering, Kerala, India*

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Abstract - *Superhydrophobic surfaces are high water repellent surfaces having a water contact angle greater than 150°. These surfaces were developed by scientists by taking inspiration from nature. There are various methods to manufacture a superhydrophobic surface, such as chemical etching, dip coating, spin coating, spray coating, sol-gel processing, electrochemical deposition, chemical vapour deposition, etc. The superhydrophobic surface shows excellent self-cleaning, anti-corrosive, anti-fogging properties. Also has good chemical, mechanical and thermal stability. The applications of the surfaces are in the fields of aerospace, automobile, ships, medical, solar panels etc. This article contains the basics of Superhydrophobicity, the developing methods, and the experimental results obtained from different pieces of literature.*

***Key Words*:** **Superhydrophobic, Water repellent, Water contact angle, Self-cleaning, Coating**

1. INTRODUCTION

Humans are generating energy by exploiting renewable and non-renewable resources in the ocean over the decades. In the current scenario, oil and gas industries and marine renewable energy companies are holding the domination in the maritime sector. However, they are losing a huge part of their economy to its maintenance. According to the reports from the US, the annual cost for repairing the structures by these companies are billions of dollars [1]. Corrosion and biofouling are the two major problems for all marine sectors ranging from ships to turbines and buoys used for ocean energy [2]. In the case of oil and gas industries, steel and low-grade alloys are mostly used to convey the media due to their good tensile strength and high weldability. But they are susceptible to corrosive attack under the acidic environment [1]. Another main issue faced by the maritime sector is the huge fuel consumption by ships which is due to the biofouling phenomenon. Most of the materials used for building hull structures are highly corrosion resistant but they are not much resistant to the microorganism in the seawater that causes biofouling. The adherence of microorganisms on the ship hull can lead to fouling influenced corrosion which gradually reduces the lifespan of the material [3]. From the international reports, corrosion consumes about 3-4 % of the GDP of industrialized countries [4]. To tackle this consequential financial loss in these sectors, suitable protective methods have been developing over the years.

In the case of corrosion protection in steel pipelines, cathodic protection, corrosion inhibitors, and various methods of protective coatings such as fusion bonded epoxy, three-layer polyolefin, bituminous enamel, asphaltic mastic have been applied. In practice, most of the techniques are expensive and not effective when used in large structures. To prevent the biofouling activity, so many methods have emerged including pre-treating the material surface and also a variety of protective coatings [1]. Among the preparation methods mentioned, no such coating has proven an effective one in real-time applications [5]. Overcoming these challenges is now a global discussion between the scientific community and industrialists. Because all coastal countries are investing more in the maritime sector including offshore wind and ocean energy for generating enormous power from renewable sources which will be a major asset in the coming years. For this, biofouling on the marine structures is the extensive challenge industries are facing [2]. With the advancement in surface coating technology, scientists have developed a high-water repellent surface that can prevent corrosive agents as well as secede micro-organisms in the marine environment.

By showing superior water-repelling property, superhydrophobic surfaces have gained major attention in the field of surface engineering [6]. These surfaces were inspired by nature eg; Lotus leaf, butterfly, scales of shark, gecko foot etc. (Fig 1.1) [7]. Superhydrophobicity is technically defined as the surface showing a water contact angle greater than 150° as seen in Fig 1.2 [6]. Cassie and Baxter were the two scientists who first reported this phenomenon in reference to the work done by Wenzel in 1936. Comparison studies were done by cassie – Baxter between porous and flat surfaces, and they reported that porous surfaces show high apparent contact angle than flat surfaces because of the maintenance of air at this interface [8].

Over the years, tremendous research has been carried out because of its broad application in industries as well as in biological sectors [9]. Anti–biofouling paints for boats, coating for solar energy panels, self-cleaning exterior paints, blood vessel replacement, wound management are some of the examples for the application of superhydrophobic coating. To obtain a Superhydrophobicity coating surface there are two main approaches., Bottom-up and Top-down. In the former approach, low surface energy materials are coated on the micro/nanostructured surface. The latter induce widespread micro/nano roughness on a hydrophobic surface having low surface free energy [10].

The various fabrication techniques to develop superhydrophobic surfaces obtained from literature are chemical etching, dip coating, spin coating, spray coating, Electro-chemical deposition, Sol-gel processing, Chemical vapour deposition, Phase separation, wet chemical reaction, Lithography, and others. Among these, some are industrially preferred due to their low cost of processing, easy procedure, and high durability coatings. Scientists are working on the methods which are complicated and having lesser number of data to obtain optimum results so that it can be applied commercially in the near future [11]

Fig -1.1: Superhydrophobicity in nature [3].

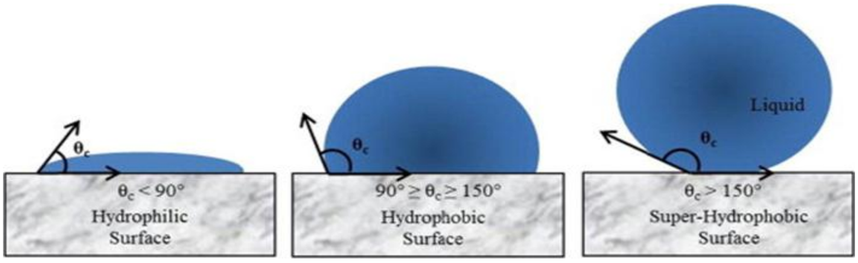

Fig -1.2: Classification of material surfaces according to their wetting angle [12].

2. EXPERIMENTAL METHODS

2.1 Etching

It is the conventional coating technique in which the metal is immersed in a mixture for some time [11]. There are two approaches in etching a) One-step process and 2) Two-step process as shown in fig. 2.1. Varshney et al. [13] studied the two-step process by immersing Al substrate in KOH solution and then in Lauric acid solution. In a one-step process, they immersed the substrate in a mixture of KOH and Lauric acid solution for 5 – 60 min. Here both roughening and lowering surface energy of Al done in a single step. Wang et al. [14] reported a synthesis of superhydrophobic film on pure Mg surface through chemical etching method. They achieved a water contact angle of 154° and a sliding angle of 3° with prominent water repellency and good chemical stability due to its flower like structures and chemical bonding.

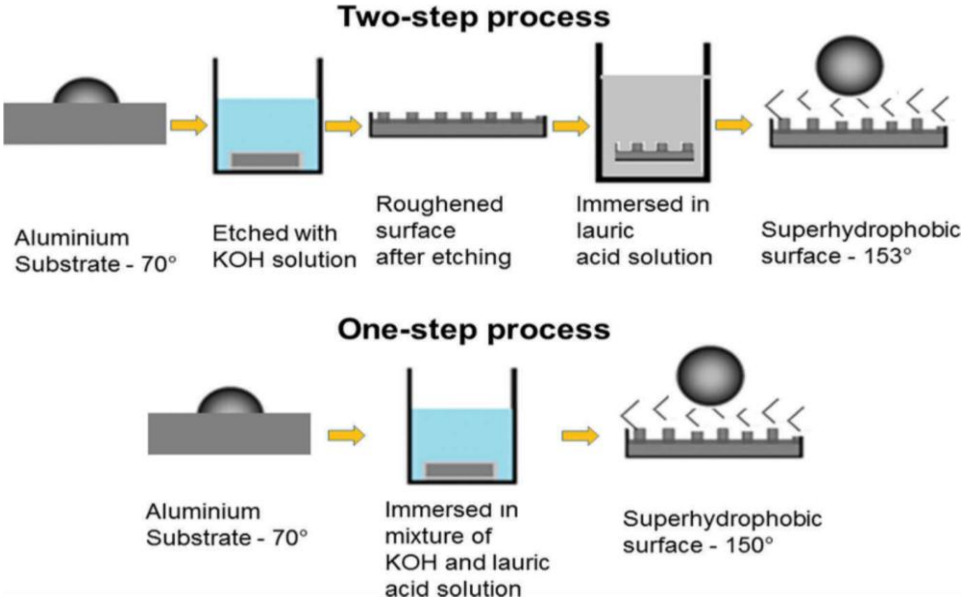

Fig -2.1: Schematic diagram of SHP coating on aluminium by chemical etching process [13].

2.2 Dip Coating

The dip coating is a continuous process in which the substrate is submerged into the solution at a constant immersion rate and the coating is developed by withdrawing the metal substrate after some time of immersion as shown in fig. 2.2. Draining of excess solution from the surface and evaporation of the solvent during withdrawing results in a surface coating [1]. Xia Zhang and his co-workers fabricated the superhydrophobic surface from a mixture of TiO_2 nanowires, Tetrahydrofluran, and PDMS on a piece of glass. Here PDMS acts as low surface energy material [15]. The speed of pulling or withdrawing plays a major role in determining the film thickness. Low speed produces thick films while high speed generates thin films [1].

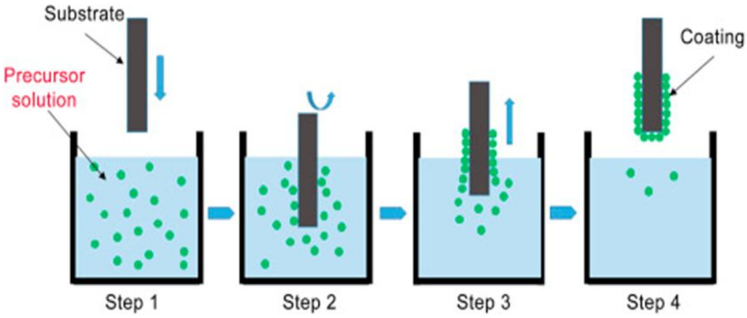

Fig -2.2: Schematic representation of dip coating technique [16]

2.3 Spin Coating

It is one of the simple coating techniques in which a solution is deposited on a substrate that is spun off at a high-velocity rate as seen in fig. 2.3. Here spinning speed describes the film thickness [11]. Mukesh Kumar Meena et al. [7] prepared polyurethane-based superhydrophobic coating on steel surface through spin coating technique. The solution was prepared from a mixture of PU, 2 – Propanol, SiO_2 HDTMS. Surface roughness was created by simple etching prior to the coating in which improves the adhesion strength of the coating. Generally, the coating is done in 3 steps; 1000 rpm for 30 s, 1500 rpm for 30 s, and finally 2000 rpm for the 60s. This technique possesses simple approach and is an excellent method on laboratory scale.

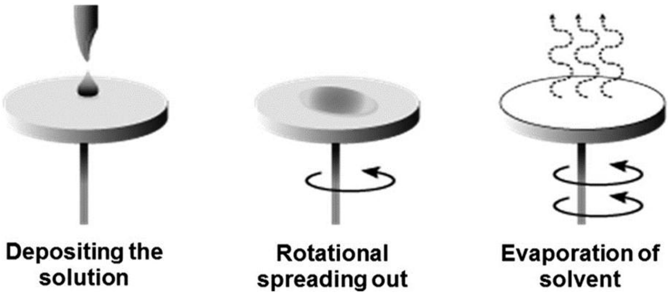

Fig -2.3: Schematic representation of spin coating technique [17].

2.4 Spray Coating

In this technique, the solution which is to be coated is sprayed onto a substrate as seen in fig. 2.4. The coating precursor requires heating or melting prior to the spraying process [11]. Kon Xu et al [18] have developed a colourful superhydrophobic concrete coating on an ordinary concrete by simple spray coating technique. They used a mixture of ament, sand, water, based stone protector, and dyes for concrete colouring. The mixture was ground into powders and sprayed onto the substrate by a sprayer with high force. Polizos et al [19] have developed a spray coating system to deposit SHC transparent silica nanoparticle film on glass substrates.

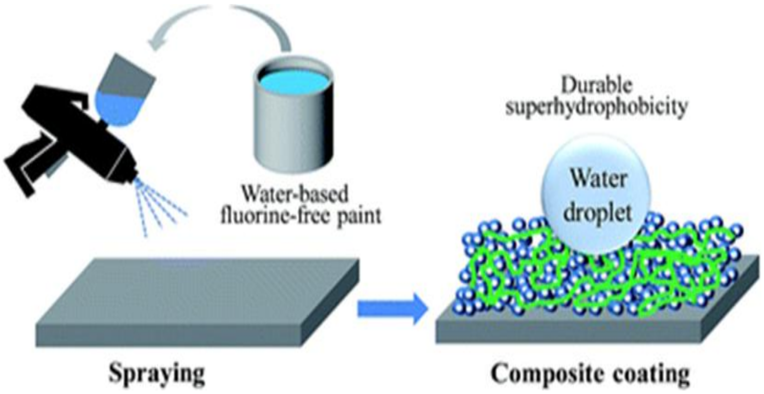

Fig -2.4: Spray coating technique [20]

2.5 Electrochemical deposition

In this, SHC coating is the result of chemical reactions of electrolytic solution which is triggered by the application of current [1]. Schematic representation of Electrochemical deposition is shown in fig. 2.5. Anodic oxidation, deposition using galvanic cell, polymerization, and electrochemical anodization, etc, are some of the production techniques that make electrochemical deposition a wide method for the fabrication of SHC [9].

Yan Liu et. al. [21] successfully fabricated SHC on a copper plate via electrochemical deposition. They had taken 2 copper for the anode and cathode. The electrolytic medium used for this process was a mixture of cerium chloride, mysteric acid, and ethanol. Zengguo Bai and Bin Zhang [22] have prepared a novel reduced graphene oxide rGO/Ni composite coating on stainless steel through electrodeposition. They deposited a thin layer of Ni on the substrate before the application of the rGO/Ni composite layer. The electrolyte they used as the medium was prepared by adding $NiCl_2.6H_2O$, orthoboric acid, potassium chloride, sodium dodecylbenzene sulfonate, and rGO. The superhydrophobic coatings were generated by the deposition of Ni on the stainless-steel substrate followed by the deposition of rGO /Ni composite mix.

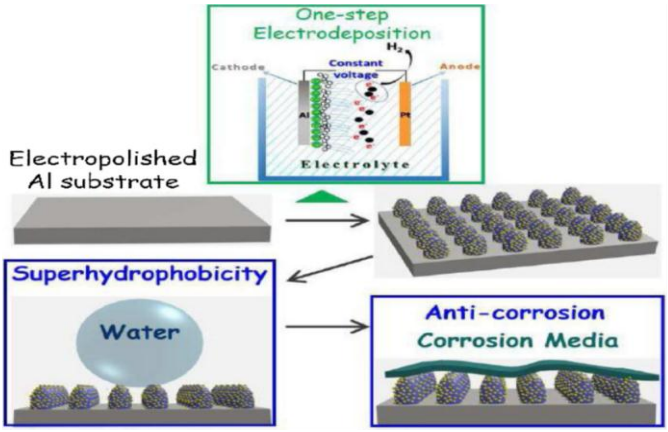

Fig -2.5: Schematic representation of electrochemical deposition coating on Al substrate [9].

2.6 Sol-gel process

The sol-gel process is the most preferred method for developing good quality coatings. The inorganic silica and organically modified silanes comprise a hybrid sol-gel that forms a 3D network to impart superhydrophobic character to the coated surface [1]. Spray coating, spin coating, and dip coating are the 3 techniques that can be used to deposit the sol-gel on various substrates [9]. Fig. 2.6 shows the schematic representation of the Sol-gel coating technique. S. Liu et al [23] reported the synthesis of transparent SHC via sol-gel processing of long-chain Fluoroalkylsilane. The coating mix was prepared by adding ethanol (solvent), ammonia (catalyst), and water. The final super repellent surface was achieved by the immersion of glass in the prepared solution for different deposition times.

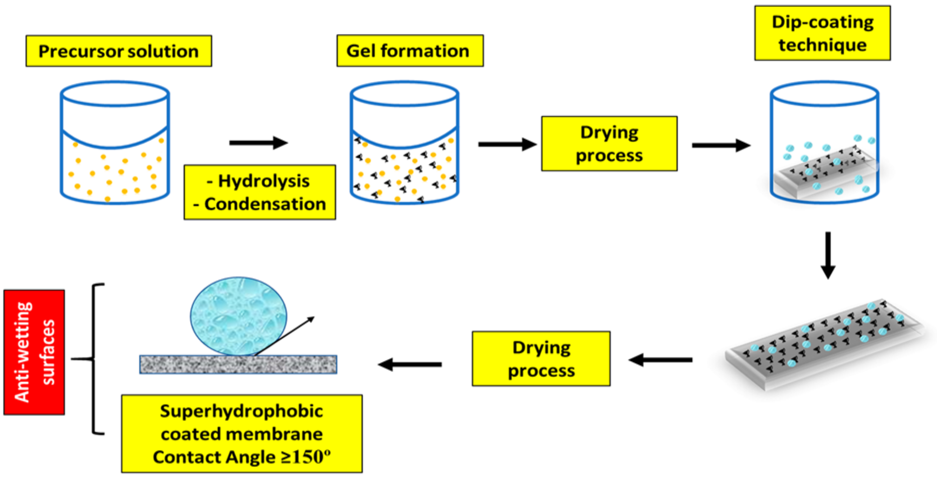

Fig -2.6: Schematic representation of sol-gel coating technique [24].

2.7 Chemical Vapour Deposition (CVD)

It is a process in which gaseous elements get deposited onto a hot substrate that is placed in a chamber as shown in fig. 2.7. A thin layer of coating is achieved under the reaction with the hot surface [11]. Zhengwei Cai et al [25] have successfully fabricated transparent SHC on the candle soot through CVD. The precursor they had taken for the deposition was MTMS and the CVD process was followed by calcination at 450°C.

Takahiro Ishizaki et al. [26] reported a synthesis of Superhydrophobic coating on AZ31 Mg alloy using Microwave Plasma – Enhanced Chemical Vapour Deposition (MPECVD). The raw materials used in the chamber were a gas mixture of trimethylmethoxysilane (TMMOS) and Ar. To obtain smooth deposition on the substrate, they had kept the partial pressures of both Ar and TMMOS constant. They also studied the relationship between water contact angle and deposition time by varying the time parameter from 10 to 30 minutes.

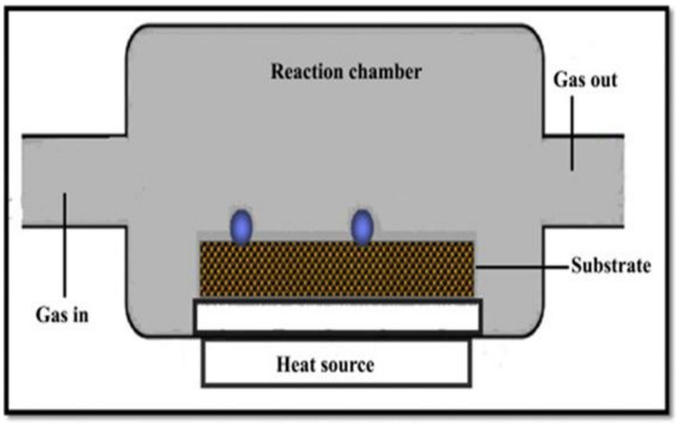

Fig -2.7: CVD chamber [27]

2.8 Hydrothermal Method

It is an in-situ coating technique that is used to produce crystalline substances from hot aqueous solutions at high vapour pressure [9]. This method can be applied to get micro nanostructured superhydrophobic features on a variety of metal substrates such as stainless steel, carbon steels, magnesium alloys, Aluminium alloys, and pure copper [1]. This reproducible technique is very effective for roughening the surface by entrapping air in the valleys between the structure, thus migrating the corrosion ions leads to improved corrosion resistance [9]. Jing Yuan et al. [28] had developed a superhydrophobic coating on an electroless plated magnesium alloy via hydrothermal method followed by immersion in stearic acid solution. The homologous solution was prepared by mixing Ni $(NO_3)_2.6H_2O$ and ethanol. The Teflon lined stainless steel autoclave had been heated up to 160°C for 9-24 hours after immersing the nickel-plated mg alloy in the solution. Finally, the sample was immersed in ethanol stearic acid solution for nanostructure modification. Shijun He et al. [29] had fabricated a superhydrophobic surface by developing micro nanostructured Fe_3O_3 on N80 steel through the hydrothermal method. They treated it at different temperature ranges from 120°C to 180°C for different reaction times. The superhydrophobic surface was obtained after annealing at 500°C for 2 hours and a water bath in ODA ethanol solution for 12 hours.

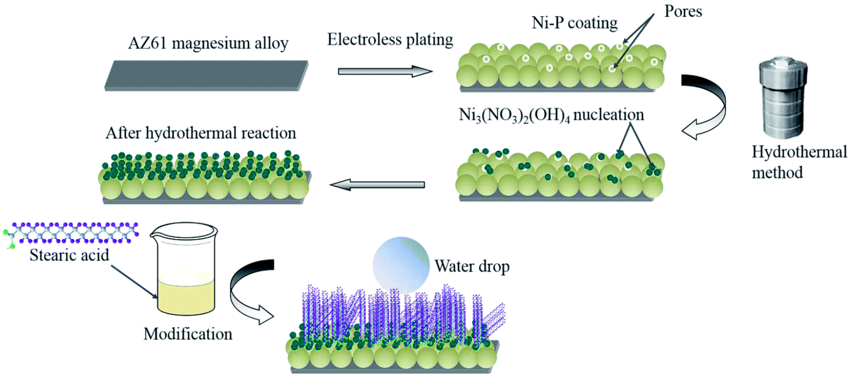

Fig -2.8: Schematic representation of hydrothermal process [28].

3 RESULTS AND DISCUSSION

3.1 SHP coating by chemical etching technique

Varshney and his co-workers [13] could obtain a water contact angle of 150° from the one-step etching process and 153° from the two-step process. They had observed the as-received aluminium and coated (modified) surfaces by SEM and the images are shown here in fig. 3.1.

Slight morphological changes were observed on the aluminium when immersing for 30 sec (fig. 3.1. (b)). When they increased the immersing time to 60 sec, craterlike micro features were seen clearly in high magnified SEM images as shown in fig. 3.1(C). The major increase in water contact angle was noticed with the increase in immersing time for both processes [13].

The effective water repellency of the superhydrophobic coating was exhibited under a high-speed water jet test as shown in fig. 3.2. The water gets spread on the as-received aluminium, but it bounces in the opposite direction on the coated aluminium surface [13].

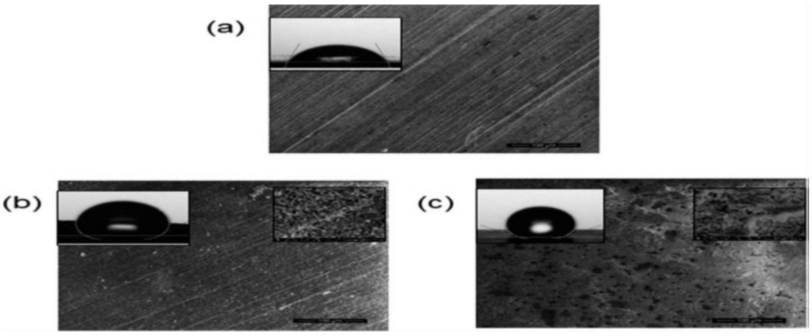

Fig -3.1: SEM images of Al surface (a) as received, and treated with KOH and Lauric acid for (b) 30 min (c) 60 min [13].

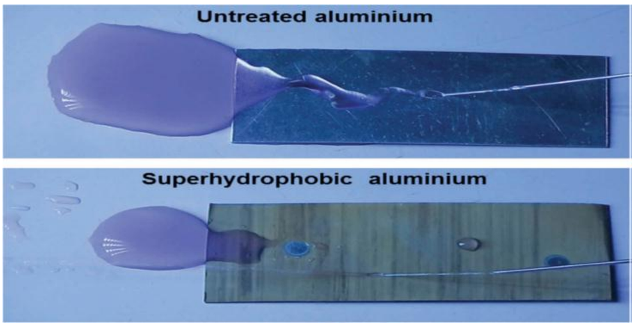

Fig -3.2: Optical images of water jet impact on untreated and superhydrophobic aluminium surface [13].

3.2 SHP surface by dip-coating technique

Xia Zhang et al could successfully generate SHP coating with a water contact angle of 158 ± 2° and a sliding angle of 5° [15].They had characterized the coated surface using TEM and SEM analysis. Fig. 3.3 displayed here shows the TEM image of the TiO_2 nanowires. From the studies, it was confirmed the solid structure of the nanowires with a diameter of 20 – 30 nm range and length of about 5 μm to more than 10 μm. The fig. 3.3 b) shows the SEM images of the coated surface and could see the accumulation of TiO_2 nanowires that form dendrites to make the surface roughened. The superhydrophobicity of the surface was clearly defined by the image of spherical droplets of water on the TiO_2 nanowire coating as u can see in fig. 3.3 C).

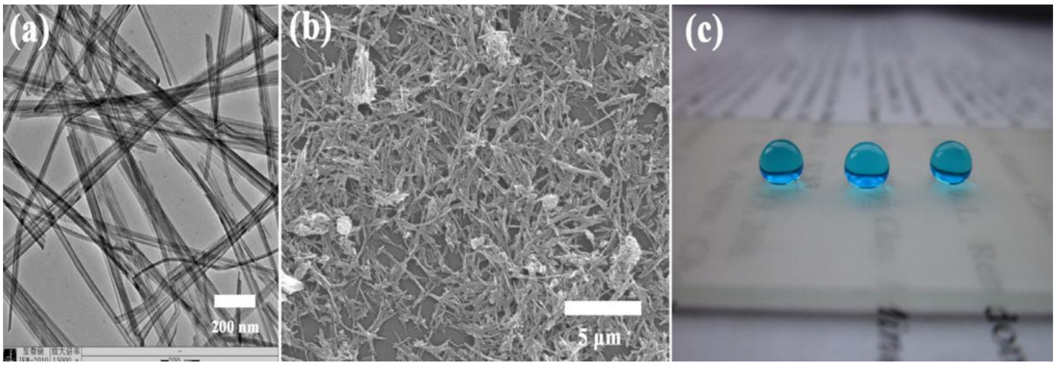

Fig -3.3: (a) TEM images of TiO_2 nanowires (b) SEM images of the as-prepared superhydrophobic surface (c) Photographs of the water droplets on the superhydrophobic surface [15].

The self-cleaning function of the superhydrophobic coating surface was studied with graphite powder as contaminants. The self-cleaning process is shown in fig 3.4. The coating which is being scratched by mechanical means can be regenerated by immersing in TiO_2 nanowire suspension and drying. The regeneration was easy and it will meet the future needs in the application of superhydrophobicity [15].

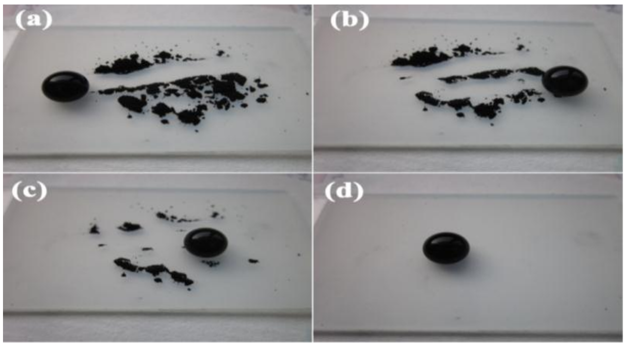

Fig -3.4: Self-cleaning process on the SHP coating [15].

The transformation studies of the superhydrophobic coating were done using ultraviolet light and could conclude that the conversion of a superhydrophobic surface to a hydrophilic one was mainly due to the surface composition and not the microstructure. The benefits of the dipping method include easy repairability, an industrial method of implementation, and applicability to make a promising practical application potential [15].

3.3 SHP surface by the spin method

The SHP coated sample prepared by Mukesh Kumar Meena et al [7] showed excellent water repellency with a water contact angle (WCA) of 165±5 ° and a tilt angle of 4 ° ± 2 °. The SEM images of both uncoated and coated steel together with contact angles are shown in fig. 3.5.

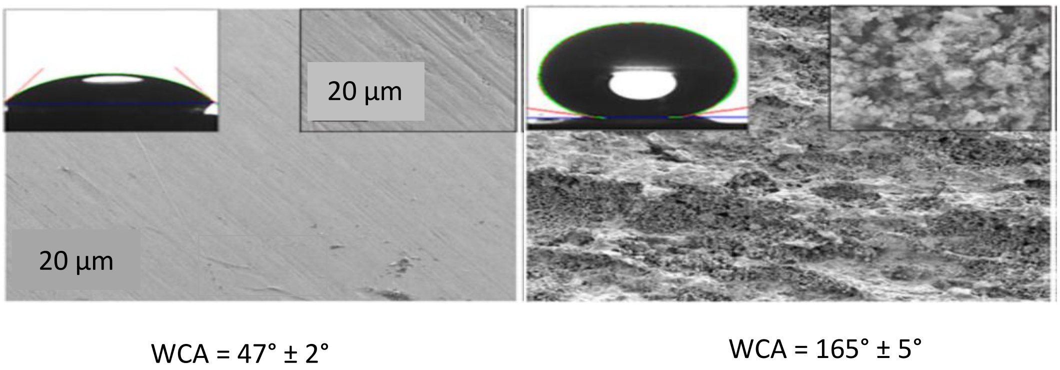

Fig -3.5: SEM images of uncoated and coated steel [7].

The floating test was done to examine the floating ability of the coated sample, the uncoated sample sunk rapidly and the coated sample to float on the surface of the water as shown in fig. 3.6. They had studied the anti-corrosion property of the superhydrophobic coating through an electrochemical experiment in Potentiostat by using 3.5 (w/v) % NaCl solution for 30min. The coated sample had shown an increase in corrosion potential and a decrease in current density as that from uncoated steel which confirmed the anti-corrosion properties of the superhydrophobic steel. The SHP coated steel exhibited excellent self-cleaning, anti-fogging and anti-corrosion properties, which makes the coating useful for many industrial applications [7].

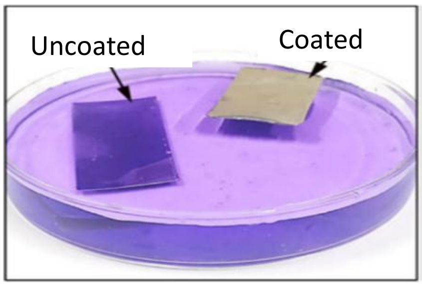

Fig -3.6: Optical images of coated and uncoated steel samples while the floating test is carried out [7].

3.4 SHP coating by spraying method

The Superhydrophobic coated surface fabricated by Kon Xu et al. [18] showed a water contact angle of 158 ± 0.5° and a sliding angle of 5 ± 0.8° as shown in fig 3.7. The coating showed high robustness and retained superhydrophobicity even after abrasion, knife scratch and tape peel. It exhibited excellent chemical stability and good durability and could resist extreme weather conditions showing anti-icing, anti-irradiation, anti-corrosion and self-cleaning capabilities. The CSC (Colourful Superhydrophobic Concrete) coating could be easily applied on large structures and is expected to have promising applications in concrete architectures.

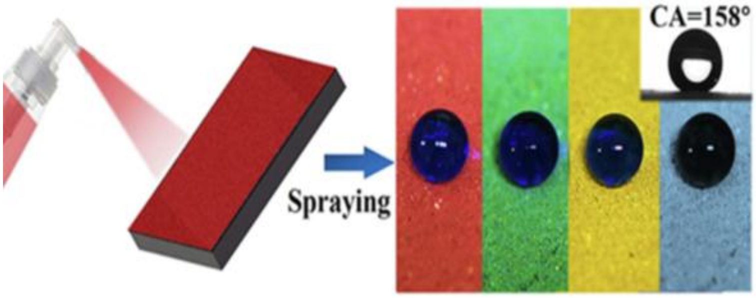

Fig -3.7: SHP coated concrete (Insert image shows the water contact angle obtained) [18].

The highly transparent, anti-soiling SHP coating developed by Polizos et al. [19], exhibited a water contact angle of 166°. Their studies showed a major dependence on water contact angle and the ratio of the polymer binder to the nanoparticle. They could achieve high resistance to falling sand which can reduce the costs of periodic cleaning of solar energy conversion systems [18].

3.6 SHP Coating by Electro-Chemical Deposition method

Yan Liu et. al. [21] fabricated a superhydrophobic surface on a copper plate through the electrodeposition method, with a maximum water contact angle of 161.7° ± 2°. They had noticed the gradual increase in contact angle when time increased from 5 to 30min. The SEM images below show the transition from irregular rod-like microstructures to hierarchical micro – nanostructures. Fig. 3.8 (c) shows larger papillae structures after 40 min of deposition.

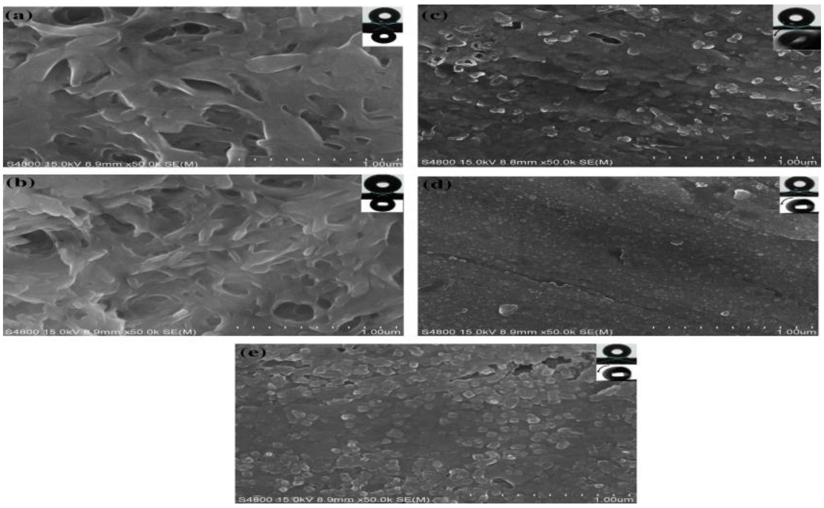

Fig -3.8: SEM images of the as-prepared surfaces at different deposition times in the electrolyte consisted of 0.038 M cerium chloride and 0.1 M myristic acid at 20v DC voltage, (a) 5 min; (b) 10 min; (c) 20 min; (d) 30 min; and (e) 40 min [21].

The chemical stability of the as-prepared surface was examined by immersing the sample in different solutions where PH ranging from 1 to 14. They observed only a small decrease in water contact angle which confirmed the chemical stability of the superhydrophobic coating [21].

Zengguo Bai et al. [22] achieved a water contact angle of 162.7 °± 0.8° and a sliding angle 2.5°± 1.0 from a superhydrophobic stainless steel surface via electrodeposition. The coating was able to withstand the durability test with a small change in the WCA for 100 cycles of mechanical abrasion. The as-prepared surface showed excellent self–cleaning properties and corrosion resistance. It is one of the simple, controllable, and economical techniques to fabricate water repellent coating with optimum surface properties.

3.5 SHP coating by sol-gel processing

S. Liu et al. [23] had successfully developed a superhydrophobic coating with a water contact angle of 169 ° and a sliding angle of less than 5. The prepared surface exhibited a rough, wrinkled, hill like morphology where the water drops could form a spherical shape. The deposition time of coating plays a major role in determining the wettability of the surface. They had observed a gradual increase in WCA with respect to the increase in deposition time of 10s,100s,300s, but there was a decrease in WCA when time increased to 600s as shown in fig. 3.9.

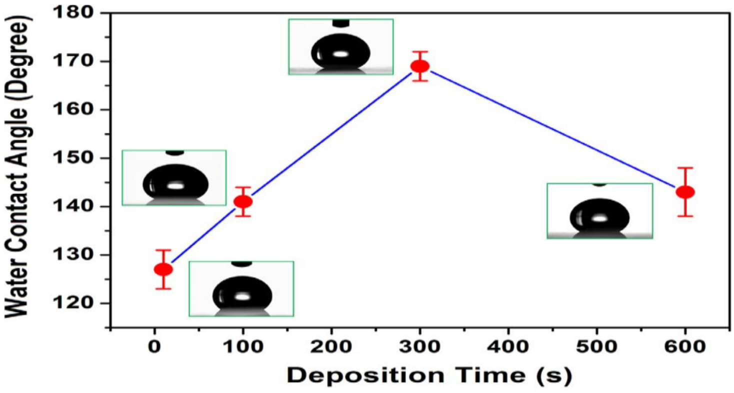

Fig -3.9: Water contact angle of coatings prepared with deposition times of (a) 10 (b) 100 (c) 300 (d) 600 [23].

As we all know that the major concern of SHP coating is its mechanical stability. The properties exhibited by the surface can be easily affected by scratches, abrasion etc. The enhancement in the mechanical stability of the coating was achieved by adding various micro/-nanoparticles in the sol-gel matrix.

Fig -3.10: Optical photograph of spherical water drops on T-3 superhydrophobic coating [23].

An optical photograph of spherical water drops on the superhydrophobic T-3 coating is shown in fig. 3.10. The developed superhydrophobic surface showed a very good ability to self-clean and such optically transparent superhydrophobic coatings are vital for self-cleaning applications [23].

3.7 SHP coating by the chemical-vapour deposition method

Zhengwei Cai et al. [25] have fabricated a highly transparent superhydrophobic hollow films and achieved a water contact angle of 165.7° and a sliding angle of 2.1°. The developed films maintained good thermal stability up to 500°C and turned into hydrophilic when the temperature had been increased to 600°C. They examined the moisture resistance of the coating by exposing it to an ambient condition for 30 days. The film had maintained the superhydrophobicity which confirmed the excellent moisture resistance property of the coating. Both thermal stability and moisture resistance is graphically shown in fig. 3.11.

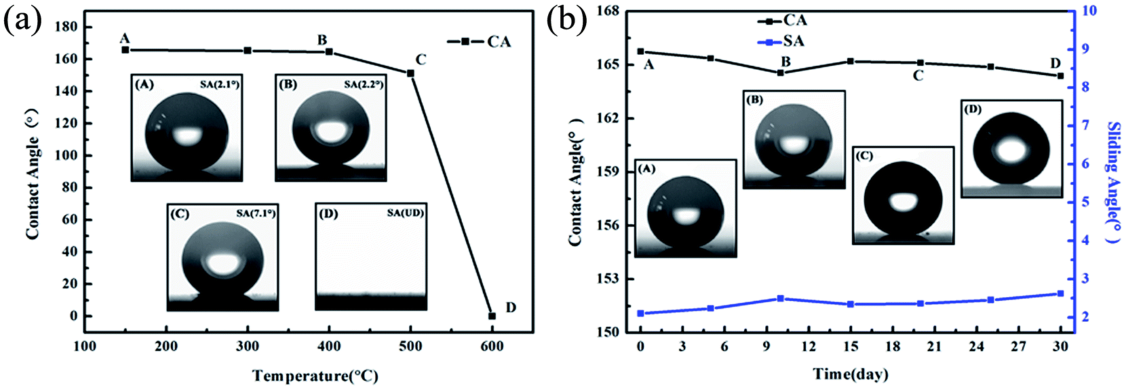

Fig -3.11: The thermal stability (a) and moisture resistance (b) of TSHF-24 film [25].

Takahiro Ishizaki and his co-workers [26] had confirmed the superhydrophobicity of the film they had prepared by the topographic studies and higher wettability of the surface. The deposition time plays a major role in determining the surface roughness and the superhydrophobicity of the coating. As time increases, water contact angle increases resulting in superhydrophobicity as shown in fig. 3.12. The decrease in current density of the coated surface by more than three orders of magnitude as that of uncoated AZ31 alloy had confirmed the improvement in corrosion resistance. The chemical stability of the coating was examined under different PH. The results showed excellent stability in both acidic and neutral aqueous solutions, but lower stability in alkaline aqueous solutions. Higher chemical stability, improved corrosion resistance were the key results they have achieved to expand the corrosion-resistant films for various engineering materials.

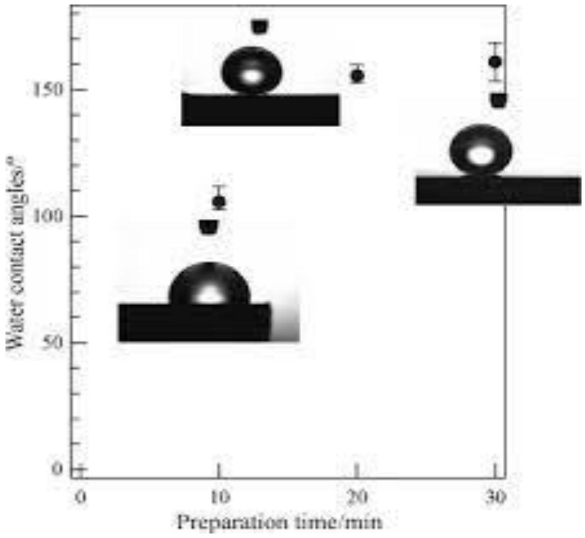

Fig -3.12: Relationship between water contact angles on the film surface deposited on magnesium alloy AZ31 and the deposition time [26].

3.8 SHP coating by Hydrothermal method

The surface fabricated by Jing Yuan et al. [28] showed a water contact angle of 155.6 ±.3° at 120°C and a sliding angle of 2°, possessed good superhydrophobicity. The SEM images of the prepared film at 120°C for different reaction times are shown in fig. 3.13. The film exhibited high mechanical and chemical stability which make them suitable for variety of applications. They had investigated self-cleaning ability of the coating using alumina powder and the reported performance was excellent.

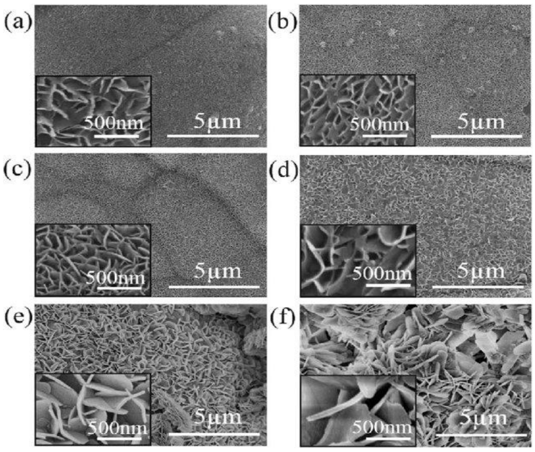

Fig -3.13: Surface morphology of samples hydrothermally prepared at 120 °C for different reaction times: (a) 9 h, (b) 12 h, (c) 15 h, (d) 18 h, (e) 21 h and (f) 24 h [28].

Shijun He and co-workers [29] had developed a thin Fe_3O_4 superhydrophobic film with a water contact angle of 158.3° and sliding angle of 3.3°. The prepared coating displayed excellent self-cleaning properties, and showed good anti-wetting ability when subjected to water jetting tests. In addition, they found out that the sample annealed in N_2-O_2 could posses superior corrosion resistance in variety of solutions. Although the testing solutions was under in different pH ranging from 2-13, there was no such large variation in measured contact angle which is shown detailed in fig. 3.14.

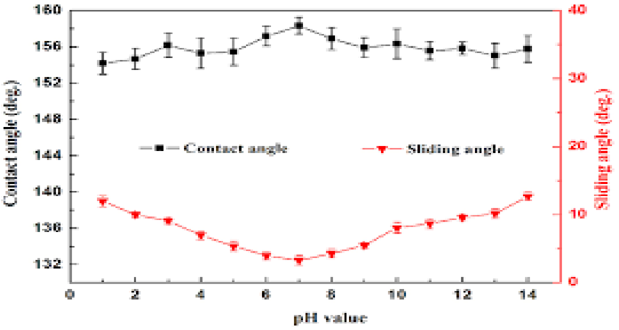

Fig -3.14: The variation of contact angle and sliding angle of the superhydrophobic sample annealed in N_2-O_2 with solution pH [29].

3.9 Advantages and Disadvantages of Superhydrophobic coating techniques

The table below concludes the major advantages and disadvantages of different coating techniques that have discussed above [7].

Methods	**Advantages**	**Disadvantages**
1.Chemical etching	Industrially feasible low cost	Non-uniform Contamination of the substrates
2.Dip coating	Simultaneous coating (Top-Bottom) Highly durable	Requires more time Only for soluble polymers
3. Spin coating	Quick-drying controllable thickness	Provides a smooth surface Only for laboratory scale
4. Spray coating	High-quality coating Repairable	Requires more capital Non-uniform thickness
5. Electro-Chemical Deposition	Time-saving Eco-friendly	Only suitable for the selected size Less control in growth
6. Sol-gel process	Provides high-quality films Synthesis at normal temperature	Limiting thickness Less durable to mechanical stress
7. Chemical-Vapour Deposition	Uniform coating Controllable thickness	High cost Not eco-friendly
8. Hydrothermal method	High quality coatings Industrially feasible	Time consuming High equipment cost

3.10 Applications of Superhydrophobic coating

Scientists and researchers have been immensely working on the superhydrophobic coating due to the increasing demand in different sectors. Most of the researches are based on the corrosion resistance coating because it is one of the major properties needed by the engineering materials [6]. This coating is being used as a protective coating for the exposed materials in maritime industries as well as in the construction sector [18]. The resistance of corrosive agents under the sea by these coatings have shown in fig 3.15. The self-cleaning property of the SHP coating is mainly applied in solar panels, mirrors, and lenses. This ability is highly exploited by the agriculture and defence sectors. The major advantage of SHP coating is that it can be applied as a transparent coating especially in glass substrates, which is mostly used for architectural purposes. Anti-reflective superhydrophobic can be deposited on the covering of solar cell system and is also employed for automobile windows and lenses etc. SHP coating possess the anti-icing potential of slowing down the adhesion of snow or ice on the surface which is being utilized by airplanes, highways, power lines, ships, etc. The paramount property of this kind of SHP surface is its anti-fouling nature. It is the more popular and commercially acceptable coating for ship hulls to protect the exterior surface of the ship's exterior, as well as to reduce the growth of organisms results in less fuel consumption [3]. Superhydrophobic coatings have been gaining more exposure in the medical sector as well. The main applications of SHP coating in the medical field are drug delivery and non-adhesion of bacteria on implants, gloves, fabrics, etc. Moreover, Superhydrophobic microfibered bandage, blood-repellent coatings, advanced textiles, and high-end footwear are some of the emerging areas of superhydrophobic coating which would be commercially available in the near future [30].

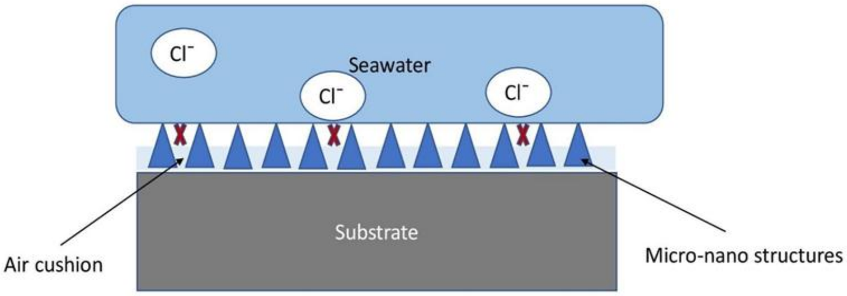

Fig -3.15: Schematic representation of anti-corrosive property of superhydrophobic coating in seawater.

4. Conclusion

Superhydrophobicity is defined by the wettability of the surface when the angle of contact of water drop on the solid is greater than 150°. This review discussed the fundamentals, synthesis processes, and achievements of the superhydrophobic coating. The phenomenon was discovered by Wenzel in 1936 which was later followed by two scientists named Cassie and Baxter. It is a bioinspired surface, eg; Lotus leaf, butterfly, scales of shark, gecko foot etc. Artificial superhydrophobic surfaces are developed by making the substrate more roughened with low surface energy. The various fabrication techniques discussed above to develop superhydrophobic surfaces are Chemical etching, Dip coating, Spin coating, Spray coating, Electro-chemical deposition, Sol-gel processing, Chemical vapour deposition, and Hydrothermal method. Among these, Sol-gel and Electrochemical deposition are the most preferred methods to fabricate SHP due to their simple generation, cost-effective approach, large scale production. Scientists and researchers have been working on SHP coating to develop a more eco-friendly coating technique having low cost and large productivity. The superhydrophobic coating has intense applications in the field of aerospace, automotive, agriculture, defence, construction and biomedical. Recent progressions in the studies of superhydrophobic surface would result in advanced technologies that will have the potential for various application in the future.

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