L.4: Glass particle deposition on steel mesh using laser for oil water separation

The laser surface texturing induced superhydrophilicity in porous or mesh-like metal substrates has great potential for efficient oil water separation and therefore can be of paramount importance in the areas where oil and water get inadvertently mixed such as oil spilling/leakage in water, industry waste water, etc. However, previously no attention has been paid to the long term stability of the induced superhydrophilicity as well as usability for oil water separation of the laser textured metallic meshes. It was observed that when the laser textured steel mesh was stored in ambient air, it completely lost its superhydrophilicity within ~75 days, and became superhydrophobic and unusable for gravity driven oil water separation. As a solution to this problem, it was observed that using a glass cover plate over the metal mesh during laser processing results in deposition of micron/submicron sized glass particles over the mesh. The glass being inherently inert and hydrophilic, when deposited in the form of micron/ submicron sized particles imparted stable superhydrophilicity to the prepared mesh.

A frequency doubled Nd:YAG laser at 532 nm with repetition rate of 18 kHz and pulse duration of ~200 ns was used for texturing. The stainless steel mesh (mesh # 300) samples were covered with a 1.2 mm soda-lime glass plate and mounted on a motorized XY-stage for scanning under the laser beam. The laser processed mesh area appeared whitish as shown in Figure L.4.1(a). This white deposition was composed of micron/submicron sized glass particles as confirmed by SEM and EDX analysis.

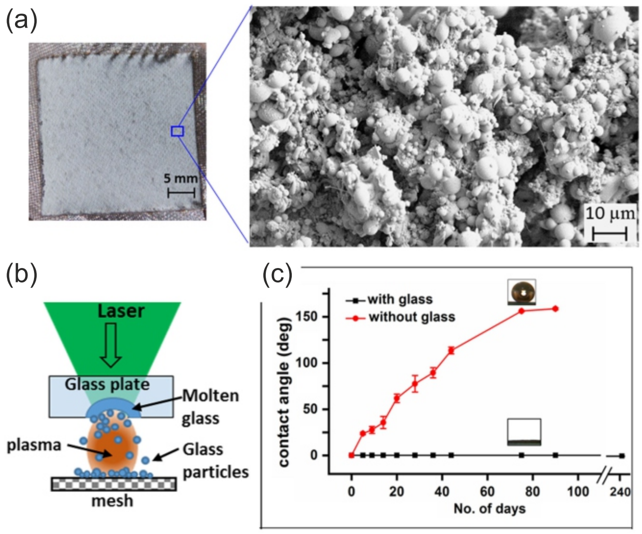

Fig. L.4.1: (a) Photograph and SEM micrograph of the laser textured mesh with the glass cover plate, (b) a schematic of the glass particle deposition phenomenon during laser processing, and (c) evolution of the contact angle of the laser processed meshes when stored in ambient air.

Such glass particle deposition might have taken place via a process known as laser induced plasma assisted ablation, in which the intense plasma formed during laser ablation of metal mesh can interact with the top cover plate and ablate it, as shown schematically in Figure L.4.1(b). Immediately after laser processing, the meshes processed with or without glass plate were found to exhibit superhydrophilicity as shown in Figure L.4.1(c). However, due to reactive nature of the metal oxides, the bare mesh gradually lost superhydrophilicity and became superhydrophobic within 75 days of storage in air, whereas the mesh processed with glass plate, i.e., glass particle coated mesh remained superhydrophilic for the tested duration of ~8 months.

When water is poured over the laser textured superhydrophilic mesh, the rough surface features of the mesh get impregnated with water and a thin film of water is formed over the mesh. When an oil droplet approaches such a pre-wetted mesh, the pockets of water trapped in the rough surface features do not allow the oil droplet to make a contact with the mesh. Thus, when a mixture of oil and water is poured over the pre-wetted mesh, the oil not being able to make contact with the mesh rises upwards, whereas the water easily makes contact with the pre-wetted mesh and gets passed through. Even when all the water is passed through, the oil remains over the mesh as long as the water film is present over the mesh. Thus, as long as the mesh is superhydrophilic, it can serve to separate oil/water mixture as shown in Figure L.4.2(a). The glass particles coated mesh could be used for oil water separation for oils like mustard oil, kerosene, and petrol with efficiency of ~96% without any significant degradation upon storage up to the tested duration of ~8 months.

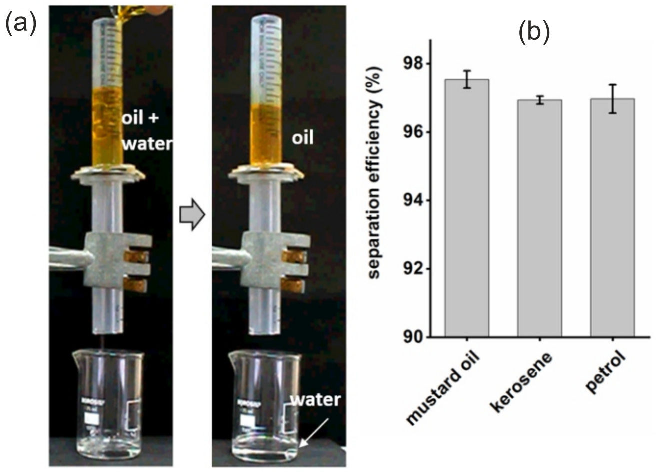

Fig. L.4.2: (a) Oil/water separation through pre-wetted glass particle coated steel mesh during and after pouring of oil water mixture, and (b) separation efficiency of mustard oil, kerosene, and petrol.

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