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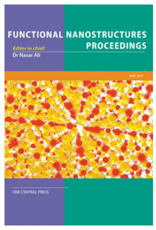

Water Vapor Extraction from Humid Air by Super-Hydrophilic VACNTs Growth on Stainless Steel Screen

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ABSTRACT

Carbon Nanotubes (CNTs) are well known for easy obtainment and great possibilities of modification. Some functionalization methods allow making the CNTs super-hydrophilics. Super-hydrophilics surfaces have great potential for water collection from fog or any other humid gas mixture. In this work, we used the CNTs wettability to develop a surface with super-hydrophobic/super-hydrophilic regions for separate water vapor from humid air. This structure has been inspired in Stenocara Namib beetle. In this work we used a self-clean super-hydrophobic surface for water condensation and a super-hydrophilic surface for water pump as the Namib's beetle. The super-hydrophobic surface was made by deposition of polyethylene (PE) on CNT/stainless screen surface. The super-hydrophilic surface was fabricated by deposition of functionalized CNTs on carbon fiber felt.

I. INTRODUCTION

Surfaces with bio-inspired structures are the most recent idea for water collection from humid air [1]. Stenocara beetle survives in Namib arid region where the dew is the only water source. It only achieves this due to the microstructure present on it shell. This microstructure consists in regions with different wettability such as hydrophobic and hydrophilic surfaces. Such a structure enable to capture droplets with diameter between 1-40 µm [2]. Fluids into microchannels can be controled though the chemical modification of the surfaces in order to obtain different features of wettability [3][4]. Surfaces with these features are of great relevance for cell growth analyze, manipulation of proteins, surface coating and ant-dew effect [5][6][7]. Garrod et.al. [2] evaluated the microcondensation efficiency of a similar structure. In their work, the authors made the structure with two polymers that were modified by plasma treatment to become hydrophobic and hydrophilic. The microcondasation efficiency was verified into a homemade weather chamber. Maestre-Valero et.al. [7] analyzed the dew collection performance of two low-cost polyethylene foils. They aimed to study techniques of dew harvesting that could help in mitigating the impact of extreme drought events in south Spain. However, the dew harvesting by means of manufactured bio-inspired structures could be a supplementary source of potable water in arid regions. In this work, we aim to study the water condensation on super-hydrophobic/super-hydrophilic surfaces.

II. EXPERIMENTAL SECTION

CNTs were grown on stainless steel screen and carbon fiber felt by thermal Chemical Vapor Deposition (CVD) method. The screens were previously oxidized in air at 650 °C. Then, the iron and cobalt catalyst particles in an ethanol solution were deposited on samples by dip-coating method. After this, we inserted the samples into a tubular CVD reactor working at 700 °C. An argon flow dragged the camphor vapor into the active zone. Functionalization step was carried out into a Microwave Chemical Vapor Deposition (MWCVD) reactor with a kitchen oven magnetron as micro wave generator [8]. Oxygen functional groups were grafted on CNTs surface by O_2 plasma. A polyethylene (PE) layer was deposited on super-hydrophobic CNTs/steel screen by dip coating method. After polymer deposition, samples were dried at 60 ºC for one hour. An experimental arrangement with a stereoscope and a nebulizer was made to observe the microcondensation on samples surface. A flow of humid saturated air reached the samples surface at 4 L/min. We used a stereoscope at magnification 100x to observe and to record the water droplets motions on samples surface. Morphologic and structural analyses were performed by Raman Spectroscopy, Scanning Electron Microscopy with Field Emission Gun (SEM-FEG). The samples wettability was verified by contact angle (CA) analyses.

III. RESULTS

The CNTs present poor adhesion on steel screen surface and the water motion could remove them. Therefore, we deposited a hydrophobic polymer layer over the CNTs aiming to solve this problem. However, the polymer deposition presents some problems, such as: the polymer layer mustn't cover the holes in steel screen and it should be thin enough to maintain the CNTs wettability.

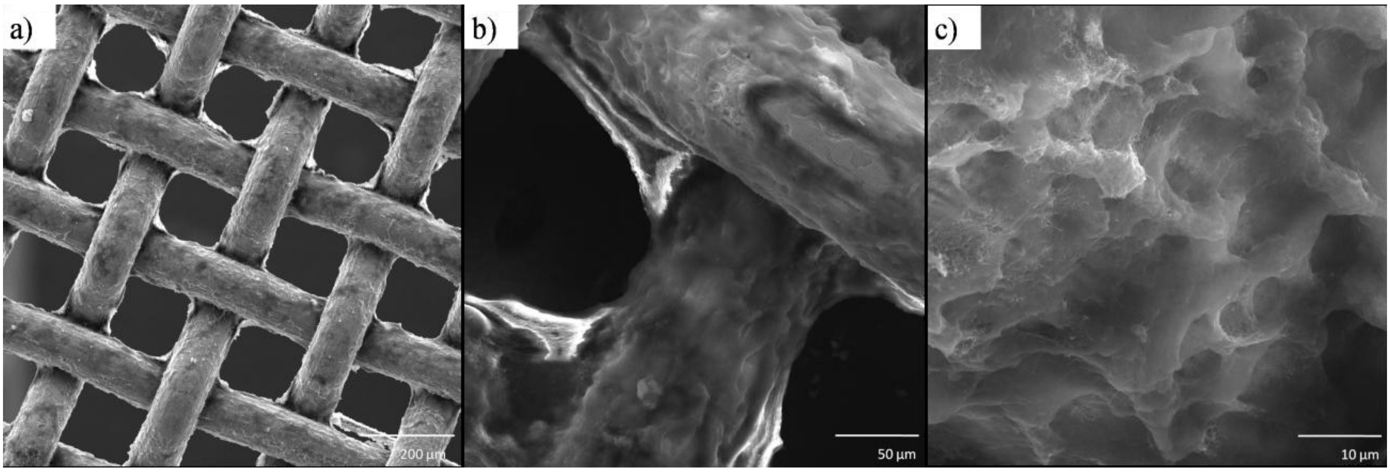

Figure 1 SEM micrographs of polyethylene (PE) layer on super-hydrophobic CNTs/steel screen at 100x (a), 1kx (b) and 5kx (c).

In Figure 1 we can see the samples after PE deposition on CNTs/steel screen. In the SEM micrograph showed in Figure 1a we can notice that PE layer didn't covered the screen holes. It is very important because water must stay in these holes after condensation and drop coalescence. Figure 1b shows that PE layer fully covered the sample surface. In addition, the Figure 1c shows that final samples surface present a different morphology than the CNTs or steel screen one.

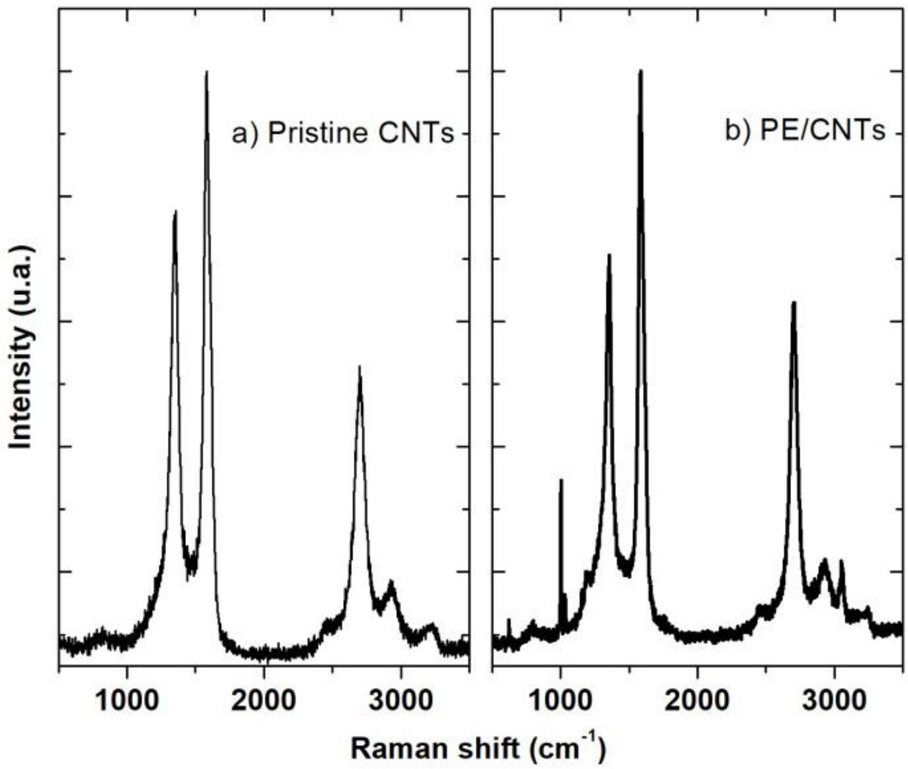

Figure 2 Raman spectra of pristine CNTs (a) and polyethylene (PE) layer on super-hydrophobic CNTs/steel screen (b) with a 514 nm laser line.

The presence of the PE layer on CNTs was verified by Raman spectroscopy. The PE/CNTs spectrum presents two significative PE characteristic peaks in addition to the CNTs ones. The first peak at arround 1000 cm^{-1} related to methylene units and the second at arround 3100 cm^{-1} due to C-H stretching [9][10].

IV. CONCLUSION

We concluded that the PE deposition was effective though SEM micrographs observation and the PE/CNTs Raman spectra analyses. Thus, we concluded that we got a new structure with potential to water collection from dew.

V. ACKNOWLEDGEMENT

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