EFFECT OF DIFFERENT MICROWAVE-BASED TREATMENTS ON MULTI-WALLED CARBON NANOTUBES

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Since carbon nanotubes (CNTs) are insoluble and inert, oxidative treatments of these materials have been frequently used for many purposes [1,2]. Many different wet and dry methods based on different oxidizing agents have been developed, but most are time consuming, expensive and require accurate control of temperature, atmosphere and reaction time. The other problem with these techniques is the lack of control of formation of the wide variety of functional groups that are introduced to CNTs [1,2].

There have been some reports about modification of CNTs with water as a mild reactive agent that selectively introduces hydroxyl groups to the CNTs [3-5]. although a high energy source is required for preparation of the reactive radicals. Absorption of MW irradiation by CNTs, for example results in such an intense heat release that the temperature can rise to close to 2000 °C in a few seconds [6]. Such interactions can be enough for preparation of reactive species for modification of nanotubes. [3].

In this work, we report the comparative effect of three different straightforward methods for modifying CNTs using a "kitchen microwave oven" and water as a reactive agent that can be easily replicated in most laboratories. In the first method, the effect of application of MW irradiation on CNTs dispersed in deionized water was studied. The second method made use of application of MW radiation to CNTs in a water vapor atmosphere. We also developed a new technique for producing plasma using an unmodified "kitchen microwave oven" and standard laboratory glassware. This method operates at relatively low pressures (~10^{-2} Torr) of a residual gas (water vapor in this report) after evacuation of the plasma chamber. In such environment water molecules disintegrate into various active hydrogen and oxygen compound radicals and can be used for functionalization of CNTs [7].

We compared results of these methods with results of thermal oxidation in controlled atmosphere and acid treatment, as two conventional methods for the functionalization and modification of CNTs. The TEM, XPS, Raman spectroscopy results, demonstrate that in comparison to acid treatment and thermal oxidation (two conventional methods for oxidative treatment of CNTs), our methods result in lower damage to the structure (Figure1.(a-f)) and more uniformity in chemical functionalization of CNTs. For example the concentration of oxygenated groups in CNTs after microwave treatment in steam was similar to thermally treated samples (most in form of hydroxyl groups) with less notable structural damage or cutting of CNTs. Although long exposure times in microwave-plasma treatment resulted in formation of amorphous carbon materials, short exposure times appeared to transform other existing oxygenated functional groups to hydroxyl groups which are useful for further chemical reactions in many applications. We also observed that the heat release in the MW-plasma method was high enough to soften even borosilicate glass, as well as soda-lime glass; therefore we successfully used this technique for welding carbon nanotubes on a range of surfaces such as polystyrene, borosilicate glass and soda-lime glass (Figure1. (g, h)) (Such microwave welding has previously been reported only for polymeric surfaces [8]).

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Figures:

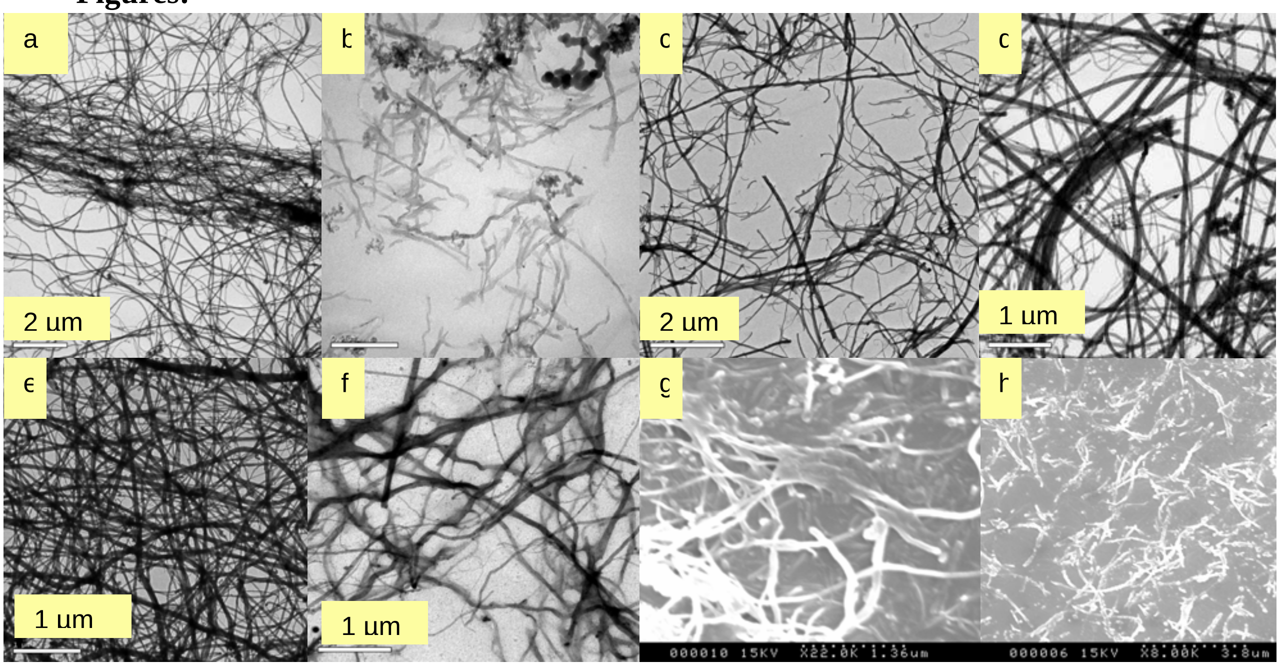

Figure 1. a) as received CNTs, b) acid treated CNTs, c) Thermally treated CNTs, d) MW treated in water, e) MW-Treated in vapor, f) MW-plasma treated after 120s, g) CNTs welded on lime-soda glass, h) CNTs welded on borosilicate glass.