Effects of multi-walled carbon nanotube materials on *Ruditapes philippinarum* under climate change: the case of salinity shifts

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Due to their increased commercial production and use, carbon nanomaterials (CNMs) will inevitably be released into the environment, with scarce information on their adverse effects, namely towards inhabiting organisms. The toxicity of carbon nanotubes (CNTs), one of the most important CNMs, is related to their physico-chemical characteristics as well as the physico-chemical parameters of the media where they are dispersed, including salinity of the aquatic systems where they may reach after release. The present research evaluated the impacts of carboxylated multi--walled carbon nanotube (MWCNT-COOH: f-MWCNTs) and unfunctionalized MWCNTs (Nf-MWCNTs), in the clam *Ruditapes philippinarum*, under control (28) and low salinity (21) conditions. Our findings demonstrated: i) a concentration-dependent toxicity in clams exposed to both MWCNT materials and both salinities, with higher metabolism, higher oxidative stress and neuro-toxicity along the increasing exposure gradient; ii) for each salinity and for each exposure concentration greater impacts were observed in clams exposed to f-MWCNTs compared to Nf-MWCNTs due to the presence of amorphous carbon fragments which can induce higher levels of toxicity to biological systems; iii) both Nf-MWCNTs and f-MWCNTs under salinity 28 generated greater alterations compared to individuals maintained under salinity 21, demonstrating that the alterations induced by salinity 28 on the chemical behavior of both MWCNTs and consequent fate in exposed clams caused major toxicity in comparison to alterations induced in organisms sensitivity due to low salinity (21).

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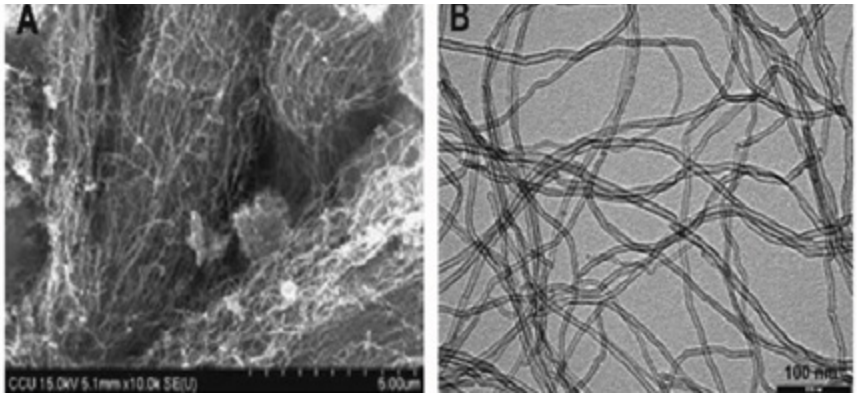

FIGURE 1
A: Scanning Electron Microscopy (SEM) of the functionalized form MWCNTs-COOH (f-MWCNTs) produced via the catalytic carbon vapor deposition (CCVD) process;

B: Transmission Electron Microscopy (TEM) of the powder form of MWCNTs produced via the catalytic carbon vapor deposition (CCVD) process