While carbon based materials attract a lot of attention for their remarkable physical and mechanical properties, it is necessary to modify their surface chemistry and wettability with functionalization for successful interaction of these materials with the surrounding medium like air, water and bio-fluids. A functionalization treatment, even small, can drastically alter the physical and chemical properties of carbon-based materials. Among strategies for functionalization, covalent sidewall functionalization is based on the rehybridization of a sp^2 carbon atom into a sp^3 configuration, is more robust, induces important modifications in the materials properties and exhibits a large range of applications such as broadband electromagnetic devices, ion storage devices, supercapacitor electrodes, sensors, composites, solid lubricants, and water desalination. Here, carbon-based membranes, initially designed and fabricated for water desalination, were functionalized with H_2 and SF_6 plasma treatments. Interesting morphological impacts of functionalization time and agent on the membranes were captured by molecular dynamic simulations, FESEM imaging, EDAX analyses and Raman spectroscopy. Above and beyond, water contact angle measurements revealed tuneability between hydrophobicity and hydrophilicity of the functionalized membranes. Electrical conductivity measurements further reflected the potential of functionalized carbon based membranes in holding back the salt, allowing fast transport of water, cancelling the conventional trade-off between selectivity and permeability, and presented these materials as candidates for new generation of nanomaterials in water desalination.