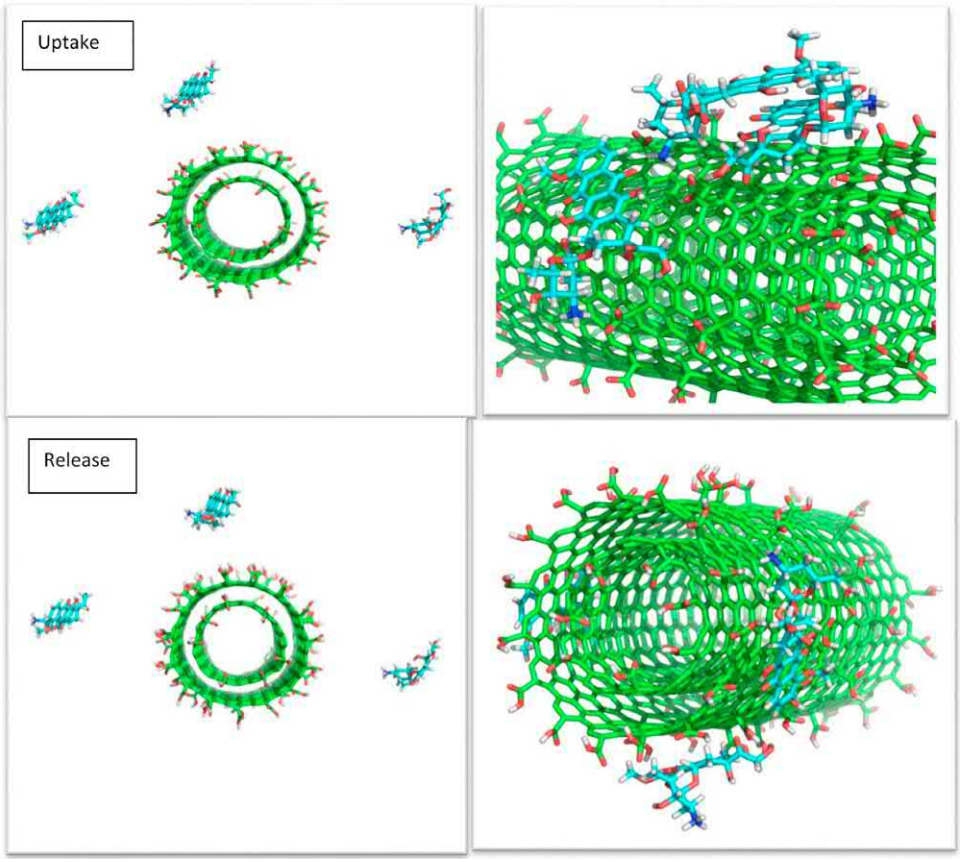

FIG. 13 The DOX loading and release using the MWCNT [58].

displayed a slower DOX release into the sarcoma tissues than the SWCNT and this was the advantageous of the MWCNT for the transport and release of DOX.

5. FULLERENES AS DRUG DELIVERY SYSTEMS

Fullerenes are promising nanomaterials that are used in numerous biomedical areas such as drug delivery, gene delivery, bioimaging, and sensors [78]. Recently, fullerene derivatives and particularly the fullerene C_{60} have attracted substantial attention as DDSs [26]. They can also be utilized in skin care formulations because they reveal high antioxidant abilities that efficiently inhibit radical oxygen species [79]. Fullerene conjugates with various biomolecule including oligonucleotides, peptides, amino acids, esters, and sugars can be used in cosmetics and drug carriers [78, 79].

The mechanism of fullerene C_{60} permeation to the skin lipid layer was investigated by constrained and unconstrained coarse grained (CG) MD simulations [80]. The skin layer composed of ceramides, free fatty acid, and cholesterol in equal molar ratios. At low concentrations in water, small fullerenes clusters, 3 and 5, were formed which were spontaneously permeated into the bilayer and dispersed in its interior. In contrast, at higher concentrations in water, fullerenes were aggregated and penetrated in their aggregated form into the interior of the bilayer. Lower fullerenes concentration did not lead to major alterations in the bilayer structure but higher concentration could change the bilayer. The fullerene permeability was dependent on its concentration that was thermodynamically related to the permeation free energy and dynamically to the diffusion ability. Considering the dispersion and aggregation of fullerene, the optimum fullerene concentration was attained that could be used in cosmetics and drug transport formulations.

Systematic coarse-grained MD modeling was carried out on the fullerene interactions with cell membranes