Microtubules (MTs), the essential structural element of cells, are long filamentous hollow cylinders whose surfaces form lattice structures of αβ-tubulin heterodimers. MTs undergo frequent polymerization and depolymerization processes, during which the binding strengths between and inside heterodimers play an important role. Molecular dynamics (MD) simulations can serve as an important tool to capture sub-nanometer details of microtubules which can be very hard and expensive when one wants to do it experimentally. On the other hand, finite element analysis model enables a large spatial and temporal scale and expensive when one wants to do it experimentally. Combining those two methods paved the way for a better understanding of the static and dynamic properties of microtubules.

Thus, we carry out a variety of full atomistic simulations to investigate the interaction properties, such as adhesion energy, tensile strength, and shear strength between pairs of α and β tubulins. Those data are then used as input for the MD-based FEA model.

In our MD simulations, through comparison between wild and mutated species regarding stiffness and non-bonded interaction, we can conclude that the intra-dimer binding strength can be tuned via mutations of residues belonging to charged residue clusters.

We have also established a MD-based FEA model, validated by comparison of FEA results with MD results. This FEA model can be further extended to advancing our understanding about the static and dynamic properties of microtubule.

CONCLUSIONS

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