Integrated in silico and in vitro Experimental Strategies for the Application of Carbon Quantum Dots in Alzheimer's Research

Tsai, Alena (School: Manhasset High School)

Alzheimer’s is difficult to treat, particularly due to inability of prospective treatments to cross the impermeable blood-brain-barrier(BBB). Neurodegeneration is exacerbated by Aβ-aggregates and tau protein, caused by NMDA/AMPA/GSK3-β dysfunction. This study evaluated the potential of carbon quantum dots(CQDs), nanomaterials exhibiting BBB-crossing, in Alzheimer’s research, using methylene blue(MB) and ginkgolide-a(GA), carbon-rich, accessible substances, as precursors. Molecular docking between ligands(MB,GA) and macromolecules(AMPA,NMDA,GSK3-β), indicated strong binding affinities(>-5.0kcal/mol). MTT and caspase-3 assays assessing apoptosis were conducted using HTB-11cells. MB/GA increased cell viability and reduced caspase activity in cells exposed to Aβ(p=.001, .0002, respectively). An ELISA assessed levels of eotaxin protein, which exhibits BBB-crossing and exacerbate tau-pathology/neuroinflammation. Aβ-exposed CCD-18Co cells displayed reduction of eotaxin by MB/GA(p=.015). Assays displayed MB/GA’s potential to influence Alzheimer’s pathology via interactions found by docking. Finally, CQD’s were hydrothermally synthesized using MB/GA. BR6563,CL2120,CL2122 C. elegans expressing tau and Aβ respectively, were exposed to CQD’s to evaluate prevalence of neuroprotective effects. Fluorescence levels of Aβ/tau in models decreased after CQD exposure, indicating Aβ/tau reduction (p=.039). Overall, methods provide a versatile,affordable,green method of addressing Alzheimer’s pathology through CQD’s. CQD’s significantly reduced Aβ/tau expression and apoptosis in models. In-silico molecular docking allows for exploration of numerous interactions, and preliminary in-vitro validation of precursors increases chances of maintaining desired neuroprotective-effects post-synthesis.

Awards Won:

Fourth Award of $500