Computational study on the binding of L-DOPA, dopamine and oxidized derivatives to gold nanoparticles

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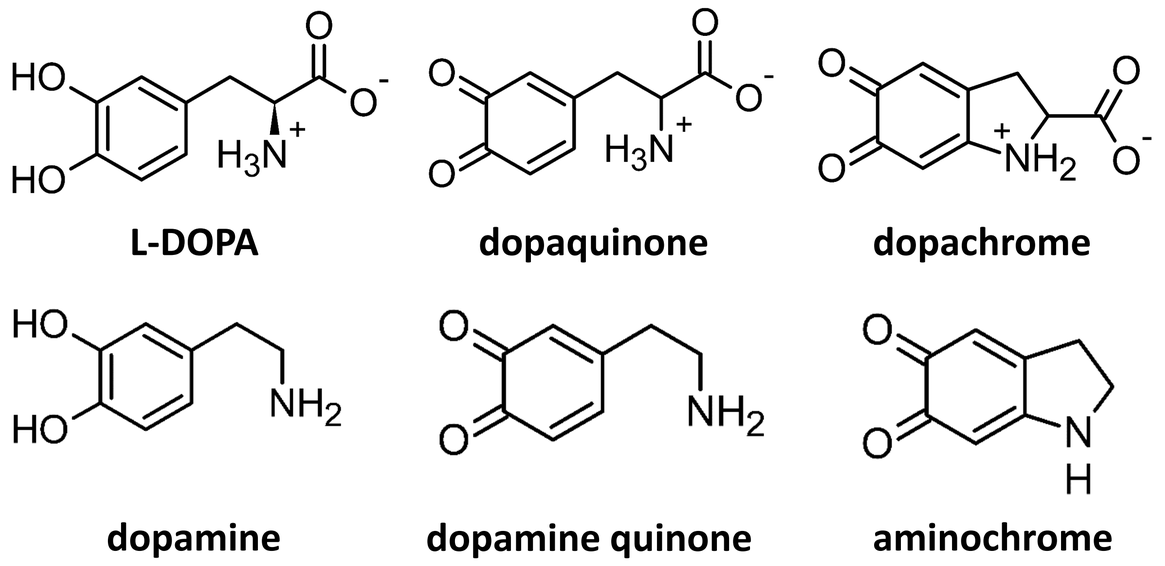
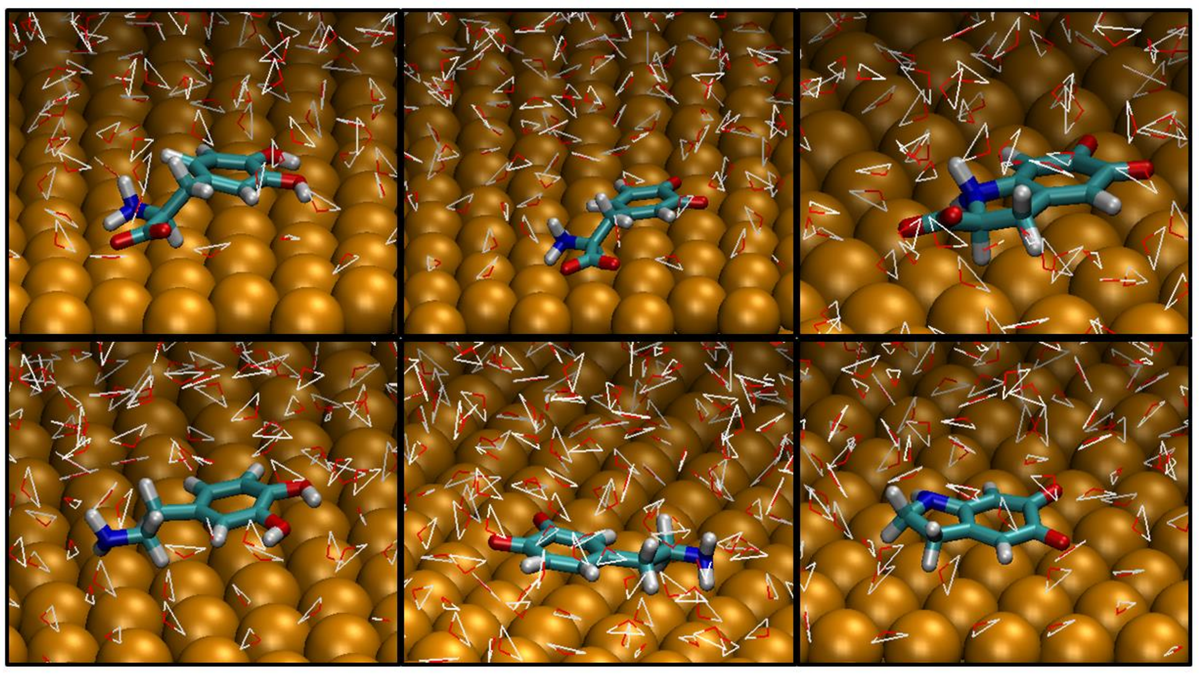
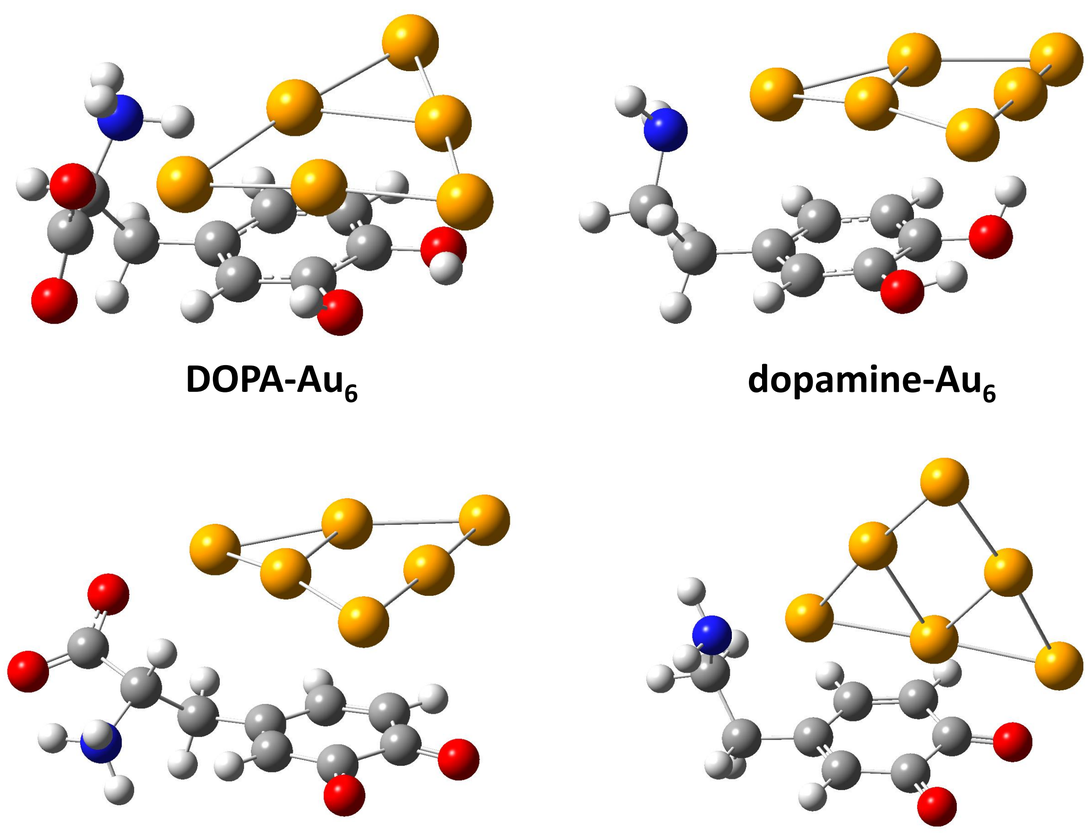
INTRODUCTION

- Novel nanodelivery systems for treatment of Parkinson's disease
  → L-DOPA and dopamine attached to the surface of gold nanoparticles (AuNPs)
  → improved delivery through the blood-brain barrier
- Preparation of L-DOPA and dopamine-coated AuNPs by the traditional reduction method
  → generation of toxic oxidation products
- Binding of toxic byproducts to AuNP surface?
  → computational study of surface events and interaction of AuNPs with L-DOPA, dopamine and their oxidized derivatives



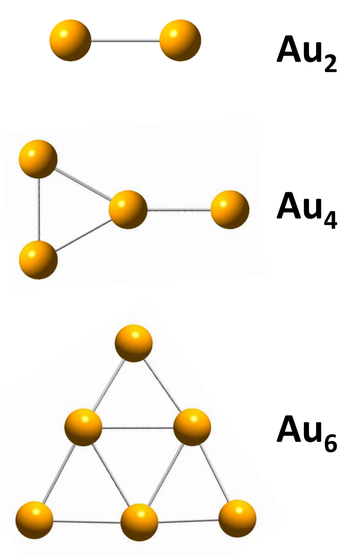


The close-up snapshots of the last frames of the production runs from classical MD simulations. Top row: L-DOPA, dopaquinone and dopachrome; bottom row: dopamine, dopamine quinone and aminochrome, all on Au(111) surface.



Calculated adsorption energies for interactions of different ligands on Au nanosurface (receptor) using structures from MD simulations.

Ligand	ΔG(bind) / kJmol^{-1}
L-DOPA	-150.2
dopaquinone	-170.7
dopachrome	-182.9
dopamine	-79.5
dopamine quinone	-88.9
aminochrome	-137.5



METHODS

- Optimization of complexes between Au_n (n=2,4,6) and L-DOPA, dopamine and their oxidized products, energy calculations → Gaussian 16, M06L/LANL2DZ
- Molecular dynamics simulations of interaction between Au(111) plates with L-DOPA, dopamine and their oxidized products including 2000 water molecules → Amber17, Interface FF, 70 ns
- Binding energies → MM-GBSA

RESULTS

- Complexes with oxidized derivatives - more stable compared to complexes with L-DOPA and dopamine
- All species spontaneously bind to AuNP surface, but oxidized derivatives with higher affinity
- Under the conditions of carrier AuNP preparation, oxidized derivatives are expected to bind in significant proportion

ACKNOWLEDGEMENT
This study was financially supported by the "Research Cooperability" Program of the Croatian Science Foundation funded by the European Union from the European Social Fund under the Operational Programme Efficient Human Resources 2014–2020 (grant HRZZ-PZS-2019-02-4323).