Binding of antibiotic drug molecules to the surface of silver nanoparticles: tight-binding DFT study

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Introduction

Bacterial resistance to traditional antibiotics is currently one of the most important public health problems. The formation of complexes of organic drug molecules associated with the surface of the nanoparticles leads to an increase in the therapeutic activity of drugs. In this work, we use automatic conformational search algorithms based on density-functional based tight-binding (DFTB) method to obtain the most energy-stable complexes formed by organic drug molecules Ceftriaxone and Doxorubicin with silver nanoparticles (about 1 nm in diameter) of various shapes.

Results and discussion :

It has recently been shown that Silver nanoparticles can enhance the antibacterial effect of antibiotics on both susceptible and resistant bacteria. Searching for the physical interactions responsible for such complexation is a difficult task as the nanoparticle is formed by transition metal atoms and it is necessary to accurately consider the polarizability of the nanoparticle. In the variety of molecular modeling approaches available nowadays, the density-functional based tight-binding (DFTB) method is unique in combining the clear hierarchy of physically sound approximations with high computational efficiency, thus being ideal for treating the systems of hundreds of atoms in reasonable time.

For this research, we use DFTB-based automated conformational searching algorithms to obtain the most energetically stable complexes formed by silver nanoparticles (ca. 1 nm diameter) of different shapes with organic drug molecules Ceftriaxone and Doxorubicin.

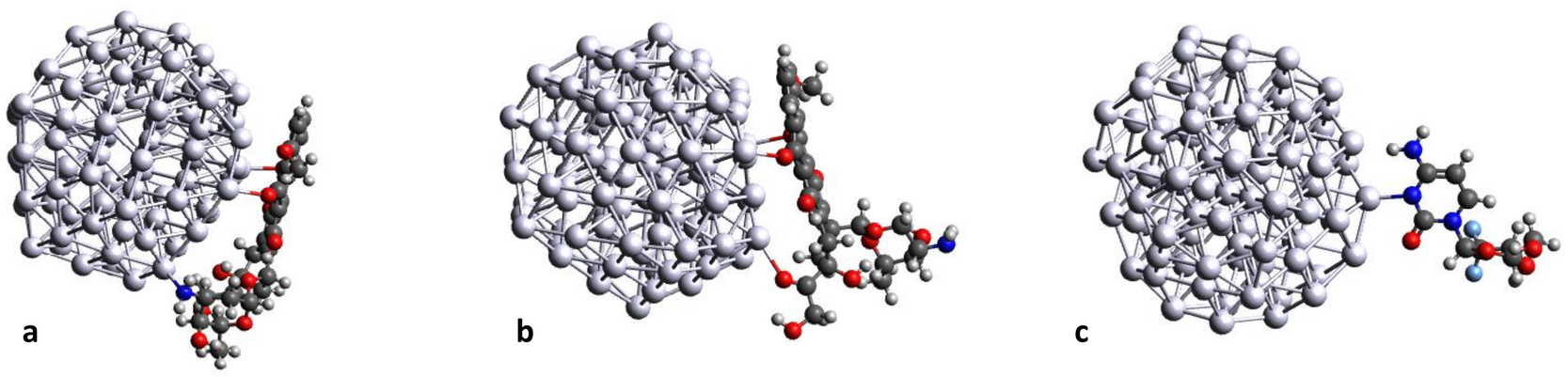

Fig.1 Complexes of Ceftriaxone(a), Doxorubicin(b), Gemcitabine(c) with silver nanoparticles of 99 atoms

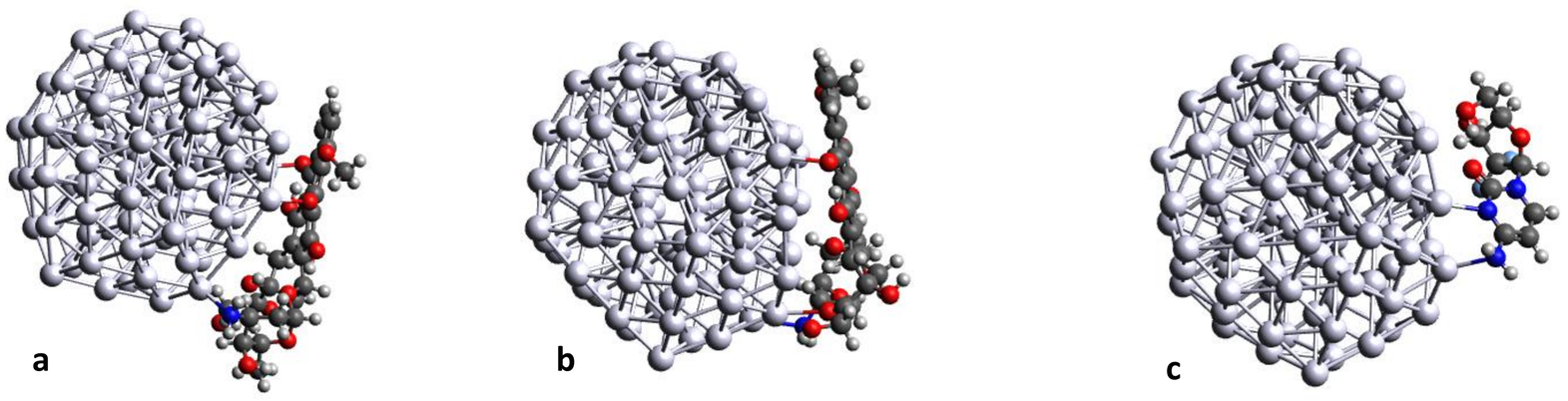

Fig.2 Most stable conformers of Ceftriaxone(a), Doxorubicin(b), Gemcitabine(c) with silver nanoparticles of 99 atoms

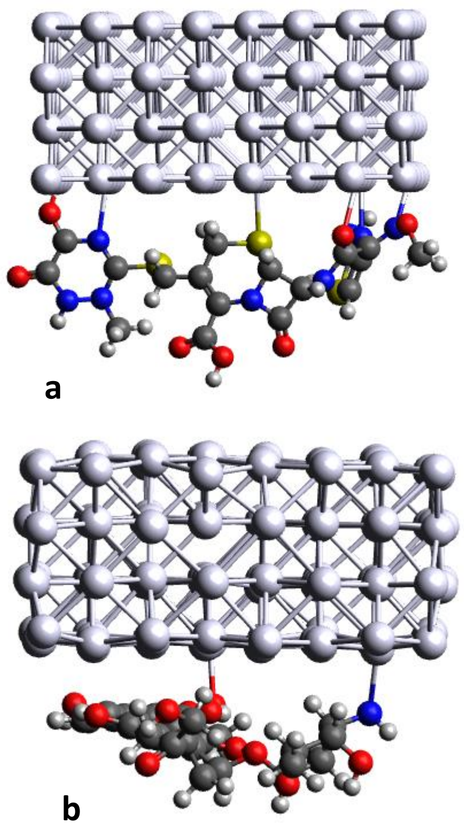

Fig.3 Complexes of Ceftriaxone(a) and Doxorubicin(b) with silver nanoparticles of 128 atoms

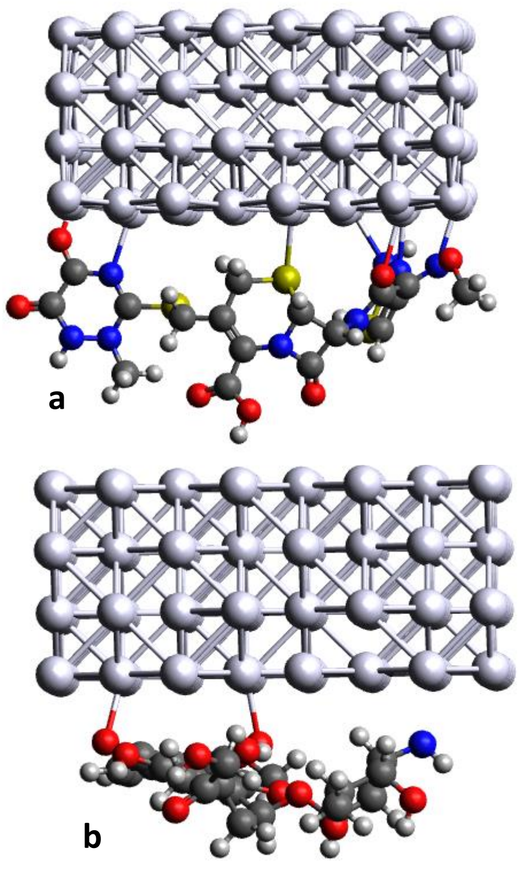

Fig.4 Most stable conformers of Ceftriaxone(a) and Doxorubicin(b), with silver nanoparticles of 128 atoms

Methods

At first, we use silver nanoparticles, that consist of 99 atoms ball-shaped and clusters from 128 atoms in parallelepiped form. We create complexes with Ceftriaxone, Doxorubicin, and Gemcitabine molecules, optimized by method GFN1-xtb with fixed Ag atoms (Fig.1, Fig.3)

After this, we use CREST utility to find conformers and to obtain the most stable complexes.

The received most stable conformers are presented in Fig.2, Fig.4

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