

A comparative DFT study on antioxidant-related properties of myricetin

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Abstract: It is well known that the antioxidant potential of a given substance can be probed through its capability to scavenge free radicals [1]. The mechanisms related to the referred activity are (mainly): i) hydrogen-atom transfer (HAT), and ii) single electron transfer (SET) [2,3]. For the HAT mechanism, it is established that the weaker the O-H bond, the higher is the antioxidant activity. The bond dissociation enthalpy (BDE) is determined as the difference in the heat of formation between the molecule and corresponding radical, and thus corresponds to the O-H bond-breaking energy. In the SET mechanism, one electron is transferred from the neutral molecule to the free radical: the lower the ionization potential (IP), the easier is the electron abstraction. Hence, probing the bond dissociation energies (BDEs) and ionization potentials (IPs) of flavonols can aid in the identification of compounds that can be applied as phytotherapeutics. In order to compute the referred properties, the density functional theory (DFT) combined with several exchange-correlation functionals have been widely used.

In a very recent study, La Rocca *et al.* [4] benchmarked twenty-one (21) commonly used exchange-correlation functionals for the determination of the BDEs and IPs for two selected molecules that are well known to present antioxidant activity: quercetin and edaravone. The conclusion was that M05-2X [5], M06-2X [6], and LC- ω PBE [7] were the preferred functionals to compute the antioxidant behavior. Hence, in the present work, we decided to apply one of Minnesota family functionals (M06-2X), LC- ω PBE and the widely used B3LYP [8] to investigate the differences among BDEs and IPs determined using these three functionals in the case of another molecule known to be antioxidant: myricetin (chemical structure is shown in Figure 1).

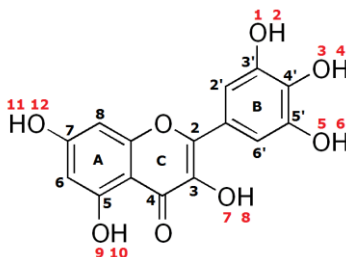


Figure 1. Representation of the chemical structure of myricetin.

Geometry optimizations, vibrational frequencies and energetics of the neutral molecule and their radicals were carried out using the B3LYP, M06-2X, and LC- ω PBE (UB3LYP, UM06-2X, ULC- ω PBE for the open-shell species) exchange-correlation



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functionals with the 6-311G(d,p) basis set [9]. Solvent effects (for *n*-hexane, ethanol, methanol, and water) were included using the integral equation formalism polarizable continuum model. The Gaussian 09 software suite [10] was the software utilized.

The smallest BDE among the six OH groups of myricetin was determined to be the O₃-H₄ for all the three functionals (in the gas phase or any solvent environment). The values obtained for the referred OH group are shown in Table 1 (IPs are also included).

	BDE			IP		
	M06-2X	LC- ω PBE	B3LYP	M06-2X	LC- ω PBE	B3LYP
gas phase	69.89	65.00	63.43	167.21	167.79	157.98
water	73.75	68.56	67.15	137.17	134.03	108.31
methanol	73.25	68.84	66.67	135.10	134.68	126.08
ethanol	73.19	68.98	66.47	135.41	135.01	126.36
<i>n</i> -hexane	70.97	74.65	64.43	151.40	151.52	142.17

Table 2. BDEs and IPs for myricetin. The values are given in kcal.mol⁻¹ and were determined using the 6-311G(d,p) basis set.

It is possible to notice that BDEs values are much lower than IPs and, thus, the HAT will play a major role over the SET mechanism in the antioxidant activity of myricetin.

In a qualitative perspective, B3LYP and M06-2X present the same order for computed BDEs (gas phase < *n*-hexane < ethanol < methanol < water) while this trend is not observed for the results determined with the LC- ω PBE (which presents: gas phase < water < methanol < ethanol < *n*-hexane). On the quantitative point of view, the B3LYP and the M06-2X BDEs differ up to 6.7 kcal.mol⁻¹ (10.0 %). In comparison to the BDEs obtained with the LC- ω PBE, B3LYP results show good agreement with differences up to 2.9 %, except for the results probed in *n*-hexane (which differ in 15.8 %). However, the referred discrepancy can be neglected since the BDEs in water are most relevant for biological antioxidant activity. Therefore, B3LYP can be considered a decent choice in terms of functional for probing the antioxidant potential of myricetin. More results will be presented in the Conference.

Key-words: Antioxidant activity, myricetin, bond dissociation energy, ionization potential, density functional theory

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References:

- [1] I. Fernandez-Pastor *et al.*, J. Nat. Prod. 79, 1737 (2016).
- [2] J. S. Wright *et al.*, J. Am. Chem. Soc. 123, 1173 (2001)
- [3] M. Leopoldini *et al.*, J. Phys. Chem. A 108, 4916 (2004).
- [4] La Rocca *et al.*, J. Mol. Model. 22, 250 (2016).
- [5] Y. Zhao and D. G. Truhlar, J. Chem. Theo. Comp. 2, 364 (2006).
- [6] Y. Zhao and D. G. Truhlar, Theor. Chem. Account. 120, 215 (2006).
- [7] O. A. Vydrov and G. E. Scuseria, J. Chem. Phys. 125, 234109 (2006).
- [8] A. D. Becke, J. Chem. Phys. 98, 5648 (1993).
- [9] M. J. Frisch, J. A. Pople and J. S. Binkley, J. Chem. Phys. 80, 3265 (1984).
- [10] M. J. Frisch *et al.*, Gaussian Inc., Wallingford CT, G09, Revision D.01 (2009).