Usefulness of Φ-order kinetics for the investigation, characterisation and quantification of photodegradation processes.

Mounir Maafi, Mohammed Alqarni

Leicester School of Pharmacy, De Montfort University, The Gateway, Leicester LE1 9BH, UK

Abstract

Φ-order kinetics has been shown to be the best tool to study photokinetics [1 – 6]. Various species have been studied using this approach including photochromes [1, 2] and drugs [3 – 6]. The unimolecular photodegradation processes of the form AB (1Φ) and photoreversible systems AB (2Φ), where A, the initial species phototransforms into a product B (A→B) which itself can return to A (A→B) via two distinct photoprocesses, each characterized each by an individual efficiency (Φ), have been mathematically described by integrated rate-law equations which express the so called 'Φ-order' kinetics [1 – 6]. The application of this novel approach was found to be useful to determine a number of photoreaction attributes. The reaction's photochemical quantum yield(s), the effects of initial species concentration, or the impact of competitive absorbers on the rate-constant of the photoactive species were all made readily accessible by simple methods. More importantly, the Φ-order kinetics has proven to facilitate the development of a wide range of actinometers from AB (1Φ) and AB (2Φ) systems [2 – 6]. This novel Φ-order kinetic method clearly has the potential for application in various fields including the photodegradation of natural products. The details of Φ-order elucidation kinetic methods will be discussed here and examples of application presented.

Keywords: Spectrophotokinetics, photodegradation; Φ-order kinetics; quantum yield; actinometry; UV/Vis spectroscopy

References:

[1] Maafi M, Brown RG. The kinetic model for AB (1 Φ) systems: A closed-form integration of the differential equation with a variable photokinetic factor. J Photochem Photobiol A: Chemistry 2007; 187: 319 – 324.

[2] Maafi M. The potential of AB (1Φ) systems for direct actinometry. Diarylethenes as successful actinometers for the visible range. Phys Chem Chem Phys 201012: 13248 – 13254.

[3] Maafi W, Maafi M. Modelling nifedipine photodegradation, photostability and actinometric properties. International journal of pharmaceutics. 2013;456(1):153 – 64.

[4] Maafi M, Maafi W. Φ-order kinetics of photoreversible-drug reactions. Int J Pharm. 2014; 471: 536 – 543.

[5] Maafi M, Maafi W. Montelukast photodegradation: Elucidation of Φ-order kinetics, determination of quantum yields and application to actinometry. Int J Pharm 2014; 471: 544 – 552.

[6] Maafi M, Lee LY. Determination of Dacarbazine Φ-Order Photokinetics, Quantum Yields, and Potential for Actinometry. J Pharm Sci 2015; 104: 3501 – 3509.