



## Studies of vitamin C antioxidative activity in the N-oxide surfactant solutions

K. Niedziółka<sup>a</sup>, M. Szymula<sup>a</sup>, A. Lewińska<sup>b</sup>, K.A. Wilk<sup>c</sup>, J. Narkiewicz-Michałek<sup>a,\*</sup>

<sup>a</sup> Faculty of Chemistry, Maria Curie-Skłodowska University, 20-031 Lublin, Poland

<sup>b</sup> Faculty of Chemistry, Wrocław University, 50-385 Wrocław, Poland

<sup>c</sup> Department of Chemistry, Wrocław University of Technology, 50-370 Wrocław, Poland

### ARTICLE INFO

#### Article history:

Received 1 November 2011

Received in revised form 24 February 2012

Accepted 27 February 2012

Available online 20 March 2012

#### Keywords:

Vitamin C

Antioxidant activity

Surfactants system

Aliphatic mono- and di-N-oxides

Atmospheric oxidation

### ABSTRACT

The results of vitamin C atmospheric oxidation in the N-oxide surfactant solutions obtained by UV-Vis spectroscopy are presented. As follows from our studies, in the solutions containing N-oxides vitamin C undergoes atmospheric oxidation more readily than in pure water and the rate of oxidation increases with the increasing surfactant concentration. The stabilizing effect of high surfactant concentration on vitamin C was not observed as it was the case of ionic surfactants: SDS and CTAB.

© 2012 Elsevier B.V. All rights reserved.

### 1. Introduction

Vitamin C (ascorbic acid, ascorbate, AA) is well known for its reducing properties. It is an excellent co-substrate in monoxygenase reactions producing hydroxylated amino acids by keeping iron- and copper-containing enzymes in their reduced states. Ascorbate is also an excellent antioxidant. It is thermodynamically at the bottom of the pecking order, thus it is the terminal small-molecule antioxidant. Ascorbate protects cells from oxidative stress by scavenging free radicals and recycling other antioxidants, such as vitamin E. There are principal reasons for suggesting that ascorbate serves an important role as a scavenger of free radicals in the human body: (a) it is known to react with oxidizing free radicals; (b) it is present in the body at sufficiently high concentrations to be effective; (c) it fits into the physiology of cellular transport and metabolism [1].

Antioxidative properties of ascorbate are also useful for protecting food, personal care products and pharmaceuticals against oxidation though its action is limited by the extremely low stability. In the literature there are numerous reports about the aerobic degradation of AA in aqueous solutions [2–5] and in the systems containing various organic additives characteristic of commercial products [6]. As follows from these reports with free oxygen

accessibility and  $\text{pH} > \text{pK}_{\text{a}1} = 4.2$  [7] ascorbic acid content in the aqueous solution diminishes to almost zero after several hours [3,4,8]. If the ascorbic acid solution is kept in the sealed vessel in dark its decomposition is much slower [6,9]. The main factors influencing the capability of AA to react with oxygen are the solution pH, temperature, light and the microenvironment composition and structure. The increasing pH and temperature always speed up the reaction whereas the additives such as organic solvents and/or surfactants may act differently depending on their type and concentration [2–6,8,9]. To modify solubility and reactivity of vitamin C in nonaqueous media *alkanoyl-6-O-ascorbic acid esters* were synthesized and their antioxidative properties were characterized by different methods [8,10,11]. LoNostro et al. [10,11] found that no matter how long the hydrophobic chain is all esters exhibit the same antioxidative activity as vitamin C.

Different products protected by antioxidant vitamins contain simultaneously surfactants acting as stabilizers, emulgators, solubilizers, etc. Surfactants used for these formulations are expected to be safe and pure. They should not reduce the activity of ingredients. It follows from our previous studies on antioxidants behaviour in the heterogeneous systems that various surfactants modify their activity in different ways depending on the surfactant type and concentration (below and above the CMC) [3,4]. For anionic SDS (sodium dodecyl sulphate) and cationic CTAB (cetyl trimethylammonium bromide) the rate of vitamin C oxidation increases with the surfactant concentration up to the CMC and then decreases. Much above the CMC the oxidation process becomes even slower than in pure water. Such effect was not observed in the solutions of

\* Corresponding author. Tel.: +48 81 5375652.

E-mail address: [Jolanta.Narkiewicz-Michalek@umcs.lublin.pl](mailto:Jolanta.Narkiewicz-Michalek@umcs.lublin.pl)  
(J. Narkiewicz-Michałek).