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Oxygen solubility in oils: Original measurement using a non-invasive optical sensor

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ABSTRACT

The amount of dissolved oxygen (O₂) in oils is one of the major factors that affect the extent of oxidation reactions of poly-unsaturated fatty acids (PUFA). Few data are available in the literature for non-polar media, most part dating from 30 to 50 years, and essentially on carbohydrates and olive oil.

The usual techniques measure the partial pressure of O₂ which can be converted into concentration of dissolved O₂ only if the Henry law constant is known. The aim of this work was to develop an experimental method to determine the Henry constants for O₂ in oils, using a portable optical device (Fibox 3, PreSens, Germany) for easy and non-intrusive partial pressure measurement. The principle is based on the quenching of luminescence using a sensor spot, and the O₂ partial pressure can be measured in gases or liquids through the glass wall of a flask.

The method discussed here is based on a conservation equation written, at constant temperature, on O₂ molecules in a closed flask, containing initially an O₂-free liquid and an air head-space. The Henry constant and the amount of dissolved O₂ in the liquid are then calculated from O₂ partial pressure measurements in liquid and gas phase at equilibrium.

The methodology was validated on water in the range of 5-50°C by comparison with published data from Winkler method. It was then applied to non-oxidizable non-polar media (dodecan, miglyol), and vegetable oils.

The results show that oxygen is 4 to 5 times more soluble in vegetable oils than in water. The impact of oil composition was also analysed.

This method makes it possible to quantify the solubility and diffusivity of O₂ in liquids and, possibly, in emulsions, and to measure O₂ consumption by PUFA oxidation during storage, which are crucial parameters for modelling the extent of oxidation reactions.