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SELF-DIFFUSION OF WATER AND OIL IN PEANUTS INVESTIGATED BY PFG NMR

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Pulsed field gradient (PFG) nuclear magnetic resonance (NMR) has been used to study self-diffusion characteristics of water and oil in natural peanuts and in peanuts saturated with water. From the dependence on diffusion time of the echo decay due to diffusion, regions of completely restricted diffusion for the oil molecules were identified. The mean size and size distribution function of these regions were obtained. Combined analysis of diffusion data for peanuts with natural moisture content and for water saturated peanuts shows the cellular nature of these regions. The cell structure, consisting of a cell cavity surrounded by a double membrane was identified. © 1998 Elsevier Science Inc.

Keywords: **Pulsed-field gradient; Restricted diffusion; Porous media; Cell structure.**

INTRODUCTION

The application of pulsed field gradient (PFG) nuclear magnetic resonance (NMR) to the investigation of biological systems is motivated by the successes of this technique for study of the structure of porous media,[1] as well as of characteristics of molecular mobility in heterogeneous systems.[2] Thus, PFG NMR can give unique information about structure and dimensions of the biological objects under investigation.[3–8] The main purpose of the present work was the investigation of the cell structure of peanuts, using strong magnetic field gradients.

The shelled peanuts (*Arachis hypogea*) used for investigations were tightly packed into a glass tube and sealed. The initial water content, determined by weight, was 6%. To obtain additional information, a sample of oil pressed from the peanuts and a sample of peanuts saturated with water to 35% were investigated. Saturation was accomplished by keeping the peanuts in water at room temperature for 24 h.

Measurements were performed on home-built equipment working at a proton frequency of 64 MHz and with a maximum PFG of 200 T/m. A stimulated-echo pulse sequence was used. Diffusion time, t_d, was varied from 5 to 3000 ms and gradient pulse duration, δ, from 0.1 to 0.3 ms; thus, the conditions for the short-gradient pulse limit were fulfilled. These parameters provide spatial resolution, $q = (\gamma\delta g)^{-1}$, down to 0.07 μm. Temperature was kept at 30 ± 0.5°C. The decay of echo amplitude due to diffusion and average self-diffusion coefficient (SDC) were the measured values. Average SDC was determined from the initial slopes of the decays plotted against $(\gamma\delta g)^2$. The precision of SDC's and component fractions is 5–15%.

EXPERIMENTS

The sample of pure peanut oil gave uni-exponential diffusion decay over two decades, independent of diffusion time. Thus, diffusion in peanut oil is characterized by a single SDC equal to $1.34 \pm 0.06 \times 10^{-11}$ m^{2}s^{-1} at 30°C. Typical experimental diffusion decay results are shown as functions of $(\gamma\delta g)^2$ for five t_d values in Fig. 1.

The main feature of the observed echo decay due to diffusion in peanuts is the transition from uni-exponential decay at short t_d to multi-exponential form at long t_d. For $t_d > 200$ ms, normalized decay does not depend on diffusion time, indicating completely restricted diffusion.[4] The initial slope is constant for $t_d > 120$ ms, giving $D_s(t_d) \propto t_d^{-1}$, as shown in Curve 1 of Fig. 2. Applying the equation[2]:

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