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Porous media characterization by PFG and IMFG NMR

Albina R. Mutina *, Vladimir D. Skirda

Department of Molecular Physics, Kazan State University, Kremlevskaya Street, 18, 420008 Kazan, Russia

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Abstract

Fully and partially filled with tridecane quartz sand was studied by different NMR techniques. The set of NMR experiments was carried out to obtain information about porous media geometry and fluid localization in it in case of partially filled porous space. The study was done using three NMR approaches: pulse field gradient NMR (PFG NMR), DDif experiment and tau-scanning experiment. The possibility to use all three approaches to study porous media properties even at the high resonance frequency is shown together with complementarity of the given by them information. Thus, first two approaches give information about porous sizes and geometry, at the same time tau-scanning experiment allows us to obtain information about distribution of internal magnetic field gradients in the porous space and draw conclusions about fluid localization in it.

Keywords: Porous media; PFG NMR; Diffusion; Internal magnetic field; Internal magnetic field gradient distribution; DDif; Tau-scanning; Partially saturated porous space

1. Introduction

Nuclear magnetic resonance (NMR) is one of the powerful techniques to study porous media properties [1–13]. Classical NMR techniques of porous media morphology and geometry study are based, mostly, on the use of external magnetic field gradients [7–13]. In this case the features of the translational mobility of the fluid molecules contained in the porous space give information about porous media characteristics.

Today a new methodical approach is being included in the NMR study of porous systems [13–15]. This approach uses internal magnetic field gradients (IMFGs) that appear in the porous media near the porous media–diffusant molecules interface due to magnetic susceptibility difference between them. From the classical NMR (diffusometry and relaxometry) point of view, appearance of additional unaccounted magnetic field gradients leads to the wrong interpretation of obtained experimental data and demands developing of special pulse sequences to minimize IMFG contribution. On the other hand, internal fields and their gradient distribution are determined by the porous space morphology and, thus, could be used to obtain information about porous media itself. Development of the new NMR approaches based on the IMFG has obvious perspectives.

By now one experimental NMR technique has been developed by Song [15–17] that uses internal fields. The author calls the technique "diffusion decay in the internal field" (DDif). This technique is based on obtaining the information about some time-dependent function of IMFG averaging due to self-diffusion of fluid molecule confined to the porous media. The problem of internal field in porous media is discussed in a number of theoretical works also [18–20], but reasonable data are obtained only for the model systems (sphere pack, regular geometry porous space, etc.). In the present work, we continue our study of IMFG distribution in porous media by the technique we called tau-scanning experiment [4] that will be described under methods in detail.

The aim of the work is to carry out comparative data analysis of the results of three different approaches of porous media study by NMR, including 13-interval PFG pulse sequence together with techniques based on the IMFG.

* Corresponding author.
E-mail address: Albina.Mutina@ksu.ru (A.R. Mutina).

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