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High-Field, Pulsed, and Double Resonance Studies of Crude Oils and their Derivatives

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4.1 Introduction

A typical petroleum fluid can be considered as a petroleum disperse system (PDS): a hybrid of a solution and a colloidal dispersion (of crystallizing waxes, self-associating asphaltenes, etc.) (Syunyaev, 1980). Understanding the complex behavior of PDS is a challenge. Nevertheless, as stressed by Evdokimov, Eliseev, and Eliseev (2001, 2004), relatively simple experiments on only one of the PDS components can shed light on details of the structural features and transformations in such systems.

As one of the constituents of PDS, a paramagnetic phase can be the subject of interest: one gram of PDS contains 10^{16}–10^{21} paramagnetic centers (PCs) (Yen and Chilingarian, 1994, 2000). The majority of PC is concentrated in the high-molecular PDS components, such as asphaltenes, resins, and polycyclic aromatic hydrocarbons. The content of the high-molecular PDS components could reach the values of 45 wt% in native oils and up to 73 wt% in natural asphalts and bitumen. Assuming that asphaltenes and resins have a molecular weight of about 1000 Da (Yen and Chilingarian, 1994), they could contain up to one unpaired electron per molecule. Obviously, such a high concentration of PC should affect not only the paramagnetic properties of substance but (at least partially) also the other ones (the electrical qualities of PDS, for example). The analysis of the behavior of the intrinsic PC in PDS could complement the data obtained by other established analytical tools.

Figure 4.1 gives a brief look into the nature of some PCs in condensed matter. The existence of intrinsic PC in PDS is caused mainly by the presence of *d*-metals (first of all V, Ni, Fe) and stable "free" radicals (FR) in PDS. It is usually

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