Electroviscous Effect in Porous Polystyrene Plugs

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Abstract

The disagreement between the experimentally determined hydrodynamic coefficients (L_{11}) of the polystyrene/methanol-water (50% v/v) mixture for different electrolyte concentrations, and those predicted by the classical treatment of Overbeek [1], is explained on basis of an electroviscous effect.

Introduction

The presence of an electrical double layer around the colloidal particles that form a porous plug exerts a profound influence on the flow behaviour of the fluid that crosses the plug [2]. All such influences are grouped together under the name electroviscous effects. For steady flow under an applied pressure gradient (in the absence of an externally applied electric field) an induced streaming potential gradient will be established [3]. This potential will produce a backflow of liquid by the electroosmotic effect, and the net effect is a diminished flow in the forward direction. The volumetric flow rate will be reduced, which will result in an apparent viscosity higher than that shown by the liquid phase in the absence of double-layer effects (e.g., at high salt concentration). This distortion of the electrical double layer implies an energy dissipation mechanism called the primary electroviscous effect, which manifests itself as an increased viscosity of the suspension. At small values of the electrokinetic radius the double layers on capillary walls cannot develop properly. These double layers overlap and the viscosity of the fluid increases as a result of double-layer interactions. This is called the secondary electroviscous effect. Both electroviscous effects are properties that are strongly influenced by ionic strength and surface charge density [4, 5].

Elsewhere [6], it was suggested that a possible electroviscous effect might explain the disagreement between the experimentally determined hydrodynamic coefficients (L_{ij}) of a polystyrene/methanol-water (50% v/v) mixture for different electrolyte concentrations, and the predictions of the classical theory of Overbeek [1]. With the goal of establishing the real influence of electroviscous effects on the coefficient L_{11} of a polystyrene-methanol-water system, the apparent viscosity of this system has been obtained.