科技导报 » 2014, **Vol. 32** » Issue (27): 23-27 DOI: 10.3981/j.issn.1000-7857.2014.27.003

**研究论文**



# 微圆管中流体的微观流动机制

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# Mechanism of Microscopic Fluid Flow in Microtubes

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**摘要** 针对低渗透油藏储层孔隙喉道小的特点，采用管径为20、15、10、5 μm 的微圆管，以去离子水和煤油为流动介质，研究微圆管中流体的微观流动规律，分析去离子水和煤油的实验流速、有效边界层厚度与压力梯度的关系，考察壁面润湿性和流体黏度对微流动规律的影响。研究表明，微管中流体流速与压力梯度基本成线性关系，随着微管管径的减小，流体流动的非线性程度增强，且驱动压力越大，微管有效边界层厚度越小，参与流动的流体更多，有效流体边界层厚度占微管管径的比例也随之降低；微管壁面由亲水性变为疏水性后，流体流速均高于改性前，微管管径越大，作用效果越显著；改变流体黏度时，出现明显的启动压力梯度特征，实验流体黏度从2.40 mPa·s 增至10.20 mPa·s 时，对应的启动压力梯度由1.26 MPa/m 增加到6.83 MPa/m。

**关键词** ： 低渗透, 微圆管, 微流动, 启动压力梯度

**Abstract** : Low permeability reservoir usually has small pore throat.Based on this characteristic, the mechanism of microscopic fluid flowin microtubes was studied using one-dimensional microtubeswith inner diameters of 5, 10, 15, 20 μm with deionized water and kerosene as the flow media.The relationshipsamong flow rate, boundary layer thickness and pressure gradient are revealed.Microtubule surface wettabilitywas changed from hydrophilic to hydrophobic with mixtures of dimethyldichlorosilane, kerosene, and siliconearein different proportions to form four different simulated oil viscosities to study the law governing the fluid flow. The results show that the fluid flow rate hada linearrelationship with pressure gradient, but nonlinearity of fluid flow gradually increased with decrease of the microtubule diameter. Also, the higher the driving pressure, the smaller the effective boundary layer thickness, and the ratio of effective fluid boundary layer thickness to microtubulediameter decreased with pressure gradient. The fluid velocity was higher than that before modification of the microtubule wall from hydrophilic to hydrophobic,and the larger the size of microtubules, the more significant the effect. The pressure gradientincreased significantly from 1.26 MPa/m to 6.83 MPa/m when the viscosity of the flow media was changedfrom 2.40 mPa·s to 10.20 mPa·s.

**Key words** : low permeability microtubes microflow pressure gradient

**收稿日期:** 2014-06-10

**ZTFLH:** O357.3

**基金资助:**国家科技重大专项（2011ZX05051）；国家重点基础研究发展计划（973计划）项目（2013CB228002）；教育部专项（FRF-MP-B12006B）

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**引用本文:**
朱维耀, 田英爱, 于明旭, 韩宏彦, 张雪龄. 微圆管中流体的微观流动机制[J]. 科技导报, 2014, 32(27): 23-27.
ZHU Weiyao, TIAN Ying'ai, YU Mingxu, HAN Hongyan, ZHANG Xueling. Mechanism of Microscopic Fluid Flow in Microtubes. journal1, 2014, 32(27): 23-27.

**链接本文:**
http://www.kjdb.org/CN/10.3981/j.issn.1000-7857.2014.27.003 或 http://www.kjdb.org/CN/Y2014/V32/I27/23