



CHAPTER I INTRODUCTION

Silica precipitation during matrix acidization of sandstone reservoirs has become a serious problem found in the petroleum industry. During matrix acidization, the stimulating fluid, HCl and/or HCl/HF acid mixtures, is injected into a geological formation and dissolves clays and aluminosilicates in the near-wellbore region in order to increase the pore space, thereby increasing the oil productivity. The dissolution of aluminosilicates sometimes leads to silica precipitation by endothermic deposition of amorphous silica undergone during acidizing treatment. Silica precipitation can cause pore blockage that can dramatically reduce the permeability of formations and can decrease oil productivity up to 35% after acid treatments (Economide *et al.*, 1988; Bryant and Buller, 1990).

In the case study of sandstone reservoirs in the Gulf of Mexico, silica precipitation has been shown to be the main reason why acid stimulation treatments in analcime-cemented sandstone reservoirs are ineffective. The analcime-zeolite dissolution during acid treatments resulted in the appearance of a white pasty silica gel, which plugged the formations (Underdown *et al.*, 1990). Such precipitation has never been revealed clearly and satisfactorily. Therefore, there is a need to investigate a fundamental understanding of analcime dissolution and subsequent silica precipitation.

Fundamental studies of analcime dissolution in very acidic conditions have been conducted in order to better understand the mechanism and kinetics of dissolution process. Basic parameters such as pH, temperature were studied to reveal the scientific principles of dissolution phenomena (Hartman and Fogler, 2006). Recently, Gorrepati and Fogler (2008) investigated the precipitation of silica in different pH solutions. Pure monosilicic acid solutions were used to study the silica particle growth and the kinetics of monosilicic acid disappearance. It was found that monosilicic acid disappears from solution very quickly; the disappearance rate is second order with respect to the molar concentration of monosilicic acid and the silica particle size increases exponentially with time. It was also found that the disappearance rate and the silica particle growth increase as pH decreases.

Silica precipitation is very complex in nature; silica in solution can be present in many different chemical and physical forms. Besides pH, silica precipitation is also influenced by other factors such as temperature, water chemistry, and suspended solids, all of which play a crucial role in the precipitation. Recent work by other workers has found that silica precipitation in neutral conditions is enhanced by the presence of counterions such as Na^+ and Ca^{2+} and by an increase in ionic strength, indicating that the effects of ions and ionic strength also play a role in silica aggregation/precipitation (Icopini *et al.*, 2005; Pan *et al.*, 2007).

In the petroleum industry, it has been found that interstitial water in petroleum reservoirs contains a significant amount of salts and foreign metals (Na^+ , Mg^{2+} , Fe etc.) (Schechter, 1992). One could hypothesize that the existence of those ions may affect silica precipitation during acidizing treatments. However, effects of ionic strength and salt (ions) in such low pH conditions are not been well-understood.

The goal of this research is to investigate the effects of salts and ionic strength on silica precipitation in acidic conditions. The basic principles of aggregation modeling and the role of salts in aggregation/precipitation phenomena are discussed. These ionic effects can eventually be taken into considerations when developing effective matrix acidization treatments.