Lithium Recovery From Oil Gas Production Water: Current approaches, challenges and opportunities

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Highlights:

- Increasing lithium demand necessitates production from unconventional sources including oilfield brines.
- Emerging lithium extraction technology can reduce energy intensity, land use impacts, and waste generation when compared to open-pit mining.
- Recovery methods including adsorption, solvent extraction, and membrane technology have been demonstrated but challenges remain.

Keywords: Lithium recovery; adsorption; oilfield brine

INTRODUCTION

Lithium is becoming an increasingly important commodity in various industries, predominantly for the development of battery technologies for electric vehicles and energy storage systems. As the demand for lithium continues to increase, lithium recovery from unconventional sources is receiving increasing interest. Among these sources, oil and gas production water is a promising source, often containing significant concentrations of lithium up to 500 mg/L [1].

Conventional lithium production via solar evaporation and participation is only applicable in arid regions with high solar irradiation such as the conditions in Argentina and Chile. Due to the constants associated with these environmental conditions, is not a viable option to produce lithium from other unconventional sources including those from oil and gas production water. Therefore, alternative extraction methods are required, and proposed and demonstrated technologies include adsorbent-based, membrane-based, solvent-based, or combinations thereof. The use of these emerging technologies would promote resource security and geographical diversity. Furthermore, the use of brownfield oil and gas infrastructure would minimize environmental impacts and increase economic feasibility. This work evaluates the potential for oilfield waters as a sustainable lithium source, providing an overview of the current approaches, challenges, and opportunities.

METHODOLOGY

This review was compiled through a comprehensive literature search using multiple databases. Focus was placed on recent studies and reports related to lithium recovery from oilfield production water. Selected studies were evaluated to identify the current state of technology, technological efficiency, limitations, and the feasibility of scalability.

RESULTS AND CONCLUSIONS

Several methods have been proposed for lithium recovery from oil and gas production water, each exhibiting unique advantages and challenges. Solvent extraction has been widely investigated for lithium recovery from brines and involves the use of organic solvents to selectively extract lithium ions to form organic lithium complexes. Solvent extraction methods have been studied for lithium recovery from shale gas-produced water [2, 3]. Although reports indicate that recovery is technically feasible, the process requires large volumes of organic solvents and necessitates the need to first dilute the produced water due to elevated levels of dissolved solids. Proposed methods typically involve a two-stage process to first remove divalent cations which may have a higher affinity for the organic solvent than lithium [2]. Furthermore, it has been shown that the presence of long-chain alkanes can adversely affect lithium recovery and should also be removed before extraction [3].

Selective adsorption materials have also been extensively studied. Sorbents for the selective recovery of lithium from oilfield waters include manganese and titanium-based materials [4, 5]. Similarly to solvent extraction methods, increasing concentrations of organics adversely affects sorbent performance [6, 7]. Although they require less pre-treatment than solvent extraction methods, precipitation of dissolved solids is typically required. A generalized process flow diagram of a typical pretreatment process for oilfield waters is presented in Figure 1.

Membrane technology including reverse osmosis and nanofiltration, has also emerged as promising techniques for lithium recovery. These methods utilize semi-permeable membranes to selectively separate lithium ions from brine based on size exclusion principles. Membrane separation is attractive for engineering applications and continuous processing but membrane fouling and high capital costs remain significant challenges [8].

This review underscores the importance of exploring alternative sources for lithium extraction to meet increasing demand. Various methods for lithium recovery from oil and gas production water have been proposed and significant research has been performed to overcome the inherent challenges associated with hyper-saline brines, but challenges remain. Solvent extraction requires the use of hazardous chemicals and generates secondary waste streams. Adsorption materials offer an environmentally friendly alternative to solvent extraction, but adsorbent performance is highly dependent on solution pH. Membrane materials are attractive for engineering applications but are prone to fouling if pre-treatment requirements are not met. With all methods, a detailed understanding of brine chemistry and the presence of interfering contaminants are required for an efficient process.

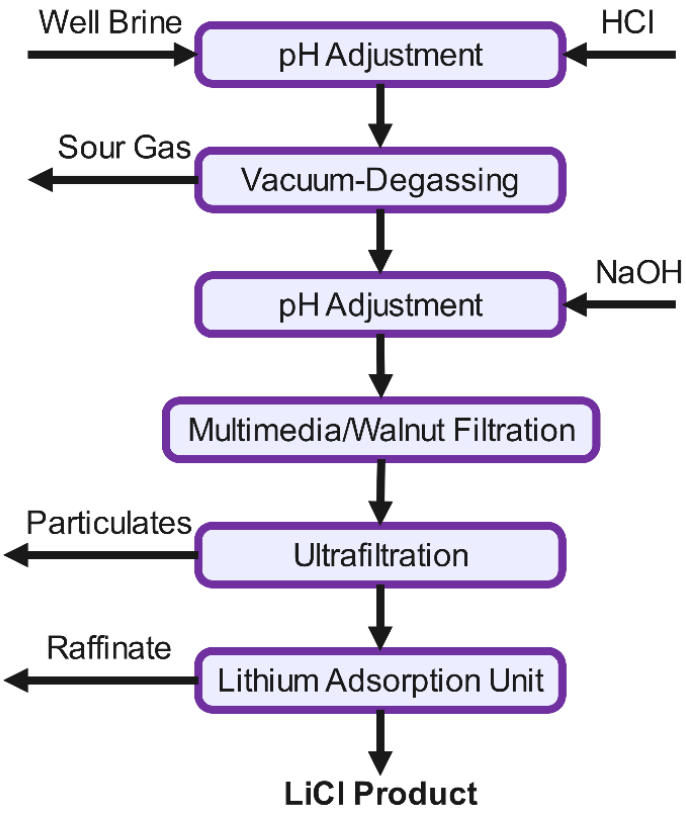

Figure 1. Generalized pre-treatment process of oilfield waters before lithium extraction process.

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