Abstract

ITN Energy Systems (ITN), along with Texas A & M University, proposes to demonstrate a proof-of-concept feasibility of a low cost, oxygen separation (enrichment) system that works on the interception effect of a gradient magnetic field in the presence of magnetic polymer beads. At present much of the oxygen enrichment market is based primarily on cryogenic systems, ion transport membranes made of ceramics, or polymer membranes technologies. All these methods have some positive and some negative attributes, but remain too expensive for the cost effective production of pure oxygen needed for clean renewable energy conversion projects. ITNs proposed system for the separation of oxygen from air using a precise application of magnetic field gradient and novel polymer magnetic matrix with encapsulated magnetic nanoparticles will improve the oxygen production for syngas synthesis, and provide a low-cost alternative to current cryogenic oxygen separation technologies. Oxygen is a paramagnetic molecule, which means that it can be influenced by magnetic fields. The proposed system forces air through chambers filled with beads of magnetic-responsive nanoparticles coated with specific polymers. The specific bead polymer chemistry along with precise control of airflow and magnetic field application will be tuned throughout the research to achieve the optimal amount of oxygen separation. System design is derived from Texas A & Ms work with theoretical molecular modeling analysis based simulation algorithms for various parameters that influence the separation under a gradient magnetic field, along with ITNs extensive experience in polymer separation membrane chemistry. With feedback from in-line sensors and detailed software modeling/analysis, the ITN team will manipulate the parameters (airflow, field strength, bead chemistry, etc.) to determine the configuration and settings that provide the best results. Our design reduces complexity and cost by using packed beads in a cylindrical column to provide an easy installation under a longer gradient magnetic field. The ITN/Texas A & M team will also perform a comprehensive analysis based on theoretical and economical practical feasibilities and scale up potential and challenges with respect to cost, efficiency, and overall benefits. ITN will focus on four strategies(1) development of polymer beads with different magnetic nanoparticles for use in magnetic columns to intercept paramagnetic oxygen molecules and at the same time enrich the polymer matrix with large volume of oxygen available for release on demand, (2) development of the module stacked with magnetic beads in different columns for oxygen enrichment, (3) assembly of a powerful magnetic field gradient system combined with necessary transducers, gas flow valves and gas driven suction pumps, and (4) development of meso-macroscoping modeling and simulation analysis algorithms for a computational system with maximum sensitivity and high yield optimization process. The newly developed oxygen separation system will be integrated with a variety of other components to deliver enhanced system performance. Successful completion of the Phase I /Phase II SBIR will establish viability of a new oxygen separation/enrichment technique with: a) Oxygen separation greater than 95%, b) Oxygen purity greater than 99%, c) Regeneration capacity of polymer beads, d) Increased overall efficiency of the oxygen separation process, e) Understanding of the effect of different magnetic field gradient values in paramagnetic gas separation, f) Computation of gas pressure, velocity and magnetic field density to achieve percolation limit, g) Cost comparison with other available technologies , h) Optimization of performance and versatility of the system for long-term in field durability.