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Iron Ore Smelting System Using a Sustainable Coal-Based Direct Reduction and CO_2 Sequestration

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This study presents an innovative system developed within the AdriatiCO2 Project for the direct reduction of iron ore via a smelting process. The system substitutes conventional coking coal with sustainable carbon sources and/or biochar—a renewable reducing agent produced from biomass pyrolysis—and integrates efficient CO_2 capture to minimize the carbon footprint of steelmaking.
In the designed high-temperature reactor, the reducing agents act as both a reductant and an energy supplier. Its high reactivity and low impurities facilitate efficient iron oxide reduction while minimizing the slag formation. The resulting CO_2 emissions are captured using post-combustion sequestration techniques, such as amine scrubbing or mineral carbonation, to ensure near-zero emissions.
Preliminary assessments indicate this approach could reduce CO_2 emissions by up to 80% compared to traditional blast furnace methods. Furthermore, the use of biochar derived from agricultural or forestry waste supports circular economy principles by valorizing biomass residues. The AdriatiCO2 Project will optimize reactor design, biochar properties, and CO_2 sequestration efficiency to enable industrial scalability. This system represents a viable transitional pathway toward greener steel production, aligning with global decarbonization goals while maintaining cost-effectiveness and material performance.

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