RAFAŁ ŁYSOWSKI

Summary

The topic of this doctoral dissertation is the production and investigation of the properties of new types of copper and iron-containing materials of perovskite and spinel-based structure, for application as solid oxygen carriers (OCs) in the chemical looping combustion (CLC) technology. CLC is an innovative, low-emission fuel combustion technology in which all the oxygen needed for the process is delivered by an OC circulating between two reactors – a fuel reactor and an air reactor.

Therefore, the material selected as a candidate for a solid oxygen carrier for this type of process should exhibit appropriate properties.

First of all, it should have a high oxygen-transport capacity during the reaction with a fuel. Another favourable property is the ability of the solid oxygen carrier to release gaseous O_2 in response to a change in the partial pressure of oxygen in the reaction environment (the so-called CLOU effect – Chemical Looping with Oxygen Uncoupling). Moreover, given the specific nature of the work environment (a fluidized bed reactor), the workpiece should exhibit sufficient mechanical strength to prevent abrasion and fragmentation.

Additionally, because chemical oxygen loop combustion technology is a low-emission technology, the oxygen carrier should be a substance with the least possible impact on the natural environment.

Solid oxygen carriers with spinel and perovskite structures are chemically stable and exhibit high mechanical strength. In addition, some of these materials exhibit the previously mentioned CLOU effect, which is particularly beneficial for the combustion of solid fuels. Such types of materials are, among others, $CuFe_2O_4$ spinel and $SrFeO_3$ perovskite.

During the research conducted in this doctoral dissertation, new materials were obtained by modifying the chemical composition of these two materials to yield compounds with higher physicochemical stability and, in the case of spinels, greater resistance to ash from the combustion of solid fuels (waste biomass).

The composition of spinels was modified by replacing some of the copper atoms with magnesium, while the composition of perovskites was modified by replacing some of the iron atoms with copper and titanium. The materials were characterized using powder X-ray diffraction methods, and their suitability for solid fuel combustion was analyzed using thermogravimetric methods.

The newly obtained perovskite-structure solid oxygen carriers were characterized by increased physico-chemical stability during multiple reduction and oxidation cycles (reduction with 3%H_2/Ar mixture, oxidation in synthetic air) at temperatures up to 1000°C.

Moreover, magnesium-doped spinel solid oxygen carriers demonstrated greater physicochemical resistance to biomass ash with high alkali metal content.