# EFFECT OF GREEK LIGNITE PYROLYSIS PROTOCOLS ON THE PHYSICOCHEMICAL PROPERTIES AND GASIFICATION REACTIVITY OF AS-PRODUCED CHARS

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**Abstract**

Coal is the cheapest and most abundant fossil fuel worldwide, with a ca. 30% share of global primary energy consumption [1]. Although lignite accounts for 45% of the world's coal recoverable reserves (5 billion tones in Greece), its applicability is limited due to its rich moisture content, low calorific value, chemical reactivity, and flammability. Therefore, the use of lignite as fuel is associated to various issues related to low thermal efficiency and high $CO_2$ emissions per produced MWh. Accordingly, alternative ways to utilize lignite, such as pyrolysis and gasification processes, are of major importance toward a more efficient and cost-competitive energy future [2].

Coal gasification typically occurs at 700 - 1200 °C and leads to a gas mixture of $H_2$, CO, $CO_2$, $CH_4$ and traces of light hydrocarbons, with its composition to be strongly dependent on the employed conditions (i.e., temperature, gasifying agent, residence time, etc). $CO_2$ gasification results almost exclusively to CO and can be regarded as a potential approach to utilize captured $CO_2$ emissions, while steam gasification enhances $H_2$ formation, resulting in a higher heating value gas mixture [3].

Char is the solid product which is yielded through coal pyrolysis, where the carbohydrate framework of coal splits into three products, namely: char (solid),

condensable vapors (liquid) and non-condensable gases [4]. The thermal treatment of low rank coals results in chars with better fuel characteristics compared to pristine fuel.

In the present work, the effect of lignite pyrolysis protocol (torrefaction and carbonization) on the physicochemical characteristics and the $CO_2$ and $H_2O$ gasification reactivity of as-produced chars is examined. A lignite coal from the Greek Western Macedonia basin was selected as fuel. Fuel samples were characterized by various methods, including ultimate and proximate analysis, XRF, XRD, BET, SEM, TGA, FTIR and Raman spectroscopy. A close relationship between the solid state properties and the gasification reactivity of lignite fuel samples was established. The lignite treated sample at 800 $^oC$ showed the optimum behavior, attributed mainly to its enhanced textural characteristics and the disappearance of C=C and C=N double bonds, as their breakage is favored upon increasing the temperature of thermal treatment. Upon $CO_2$ gasification, CO was the primary product followed by minor quantities of $H_2$ and $CH_4$ generated at lower temperatures (< 550 $^oC$) due to the release of volatiles as temperature increases. When $H_2O$ was employed as gasifying agent, a gas mixture consisting mainly of $H_2$, $CO_2$, CO and $CH_4$ was produced, with the $CO_2$ molar fraction being higher compared to CO due to the WGS reaction.

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