

## Proposed theme

**Program: Energy - FP7; EUREKA; EUROSTARS**

**Title: PILOT TECHNOLOGY AND INSTALLATION TO OBTAIN A DIESEL FUEL REFORMULATED BY CATALYTIC TREATMENT OF NON-ADDITIVE DIESEL OIL WITH HYDROGEN ENRICHED GAS**

Keywords: re-formulated diesel fuel, hydrogenation, hydro-cracking, Hydrogen Rich Gas

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We are looking for: Partners / Coordinator  
Research area: Hydrogen Chemistry  
Institution type: SME / University / Technology Transfer Centre  
Expertise: Catalysts for Hydrogenation and Hydro-cracking

### **Abstract:**

Starting from the fact that, the main means to increase the caloric power of a liquid fuel is to increase the mass concentration of hydrogen in the molecular chain. Rokura Industrial Applications Ltd. (RAI) has developed, after extensive research, a lab technology for treating different fossil liquid fuels, in normal state conditions.

The present project is based on the results of the preliminary experimental researches carried out by RAI in the period 2004-2006 ([www.rai.com.ro](http://www.rai.com.ro)). The hydrogen enriched gas obtained through RAI's technology is a mixture of H<sub>2</sub>, O<sub>2</sub> and other H-O compounds. The chemical analysis of the gas's composition indicated that Hydrogen is predominant. The physical-chemical characteristics are: colour: colourless; physical state: gas; molecular mass: 12.0kg/kmol; density: 0.503kg/m<sup>3</sup>; flammability limit: inferior – 7.3...8.7%, superior – 100% (ASTM E681); self-ignition: 597°C ...610°C (ASTM E659).

The main results obtained up to the present moment indicate the following: the Hydrogen enriched gas is easy to manufacture and use at normal temperature and pressure; the use of enriching liquid fuels at normal temperature and pressure is achieved in stability and safety conditions. The particular reactivity of the Hydrogen enriched gas components has been proved to ensure the possibility to enrich conventional fuels and, finally, to enrich their combustion properties. Connections of the initial fuels molecular chains are broken and formed, changes that prove to be stable in time, even after long storing periods. Determinations have been made on specialized stands, on non-euro Romanian internal burning engines, which highlighted the reduction of the polluting emissions, without the need to modify the adjustments or the injection/carburettor system. The analysis on the treatment products for the petroleum liquid fuels with Hydrogen enriched gas indicated an increase the H/C basic ratio (saturation of the double connections, catena rupture), simultaneously with an increase of the mass content of Hydrogen up

to 10%.

The experiments were carried out in soft reaction conditions (temperature up to 55°C and relative pressure of 1 bar). The main characteristic of liquid fuels is that they have a composition split on hydro-carbide groups which distillate at different temperatures. For diesel engines, the split composition influences the vaporizing speed of drops and self-ignition. An important characteristic of liquid fuel is the cetane number, the one that defines its self-ignition easiness. The cetane number depends in reverse proportion on the aromatic hydro-carbides content, the cetane number is increasing with the content of alkenes. The second main characteristic is the caloric power represented the heat released in the exterior by the complete burning of the quantity unit in normal state condition. When burning diesel in the internal burning engine, the analysis of the gasses evacuated in the atmosphere highlights the emission of material particles. Based on the chromatographic analyses of the particle evacuated by the diesel engine, it is noticed that carbon represents only 40%, while the hydro-carbides resulting from fuel and oil represents 30% of the total mass. The rest is represented by compounds with sulphur with molecular connected water and other compounds derived from fuel and engine lubricating oil burning.

Therefore, reducing the particle emission is strongly connected to reducing the consumption of oil and of the content of sulphur in fuel. A favourable particle emission reducing effect is also obtained by reducing the content of aromatics. Thus, the so-called “reformulated” Diesel fuels are more and more often used. Usually, it is considered that a reformulated Diesel fuel must firstly have a cetane number (CC) superior to the classically obtained fuels. A method to obtain reformulated fuel is to increase the H/C atomic ratio. The experiments demonstrated that the high ratios between the number of Hydrogen atoms and Carbon atoms, H/C, in the molecular chain, obtained by increasing the  $C_nH_{2n+2}$  content, leads to the increase of the cetane number, but only with a slight reduction in the smoke intensity. An ideal reformulated Diesel fuel is the one with an H/C ratio around the value of 2.5 and the Oxygen/Carbon atomic ratio around the value of 0.5, ratios that would decrease the smoke intensity, simultaneously with a CC between 55 and 80.

This project shall approach two technologic versions to “reformulate” by catalytic treatment of non-additive diesel with Hydrogen enriched gas: a version of continuous treating with Hydrogen enriched gas in only one phase, similar to the already existing lab installation and a version of treating in two stages the non-additive diesel. For the second version, on which all our application research efforts shall be concentrated, implies an original technological scheme based on two phases of Hydrogen enriched gas treating: a catalytic hydrogenation of the non-additive diesel stage, and a stage of catalytic hydro-cracking of the part that is to be recycled from the hydro-carbides obtained in the catalytic hydrogenation phase. After separating the catalytic hydrogenation post-reaction products, when fuel desulphurization takes place, the purification of gas with recovering the Hydrogen enriched gas is achieved. The hydro-carbides obtained in the hydrogenation phase are passed through a fractioning column where the fraction corresponding to Euro 5 diesel is evacuated, the remaining being recycled in the hydro-cracking and hydrogenating phases.

The process is restarted continuously until the entire quantity non-additive diesel reaches the quality parameters of the Euro 5 diesel: • Density at 15°C ... 0.83kg/dm<sup>3</sup>; • Cetane number >61; • Sulphur content <10ppm; • Poly-aromatics mass content <0.2%. The two technological versions will be subject to validation taking into account specific technological energetic consumptions as well as the performances of the diesel engine supplied with reformulated Diesel fuel.