Fuels – essential materials to supply energy to our society

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Among the vast variety of materials that are studied and characterized, fuels represent a special class due to their essential character to the existence and survival of our society, which require a progressively growing amount of energy to produce goods, services, food and guaranty the functioning of machines, equipment and vehicles. Although nuclear fuels and water are utilized to generate electric energy in large scale and alcohols, vegetable oils and animal fat were and still are used for energetic means, the world scene has been dominated for centuries by the wood and, subsequently, by the fossil fuels, coal, oil and natural gas. These, normally reacting with oxygen, provide the energetic potential required by liberating for human use part of the chemical energy they contain. If one considers the recent period from the Industrial Revolution on, the characteristic depicted in Figure 1 will be found. Figure 1 shows adapted drawings from Gupta [1], average energy density data [1-3], presents the years of maximum global supply for each fuel with projections from the literature [4] and an own made one and includes hydrogen as the energy vector of the future. It is worth mentioning here that hydrogen is not a primary fuel such as the other ones presented in Figure 1, because it requires a source of energy to be produced from the water, from fossil fuels or from biomass to play the role of an energy carrier.

Several important aspects can be driven from an analysis of Figure 1, such as:

1. The chemical complexity of the fuels considered decrease strongly as the years go by. Wood and coal possess chemical configurations much more complex than the fuels that came afterwards;
2. There is an important decrease on the carbon content, establishing a progressive decarbonization of the fuels used by our society;
3. The energy content that each fuel offers grows very significantly in the oil and natural gas era and have potential for a new an important leap with the use of hydrogen. The energy density values for coal, oil and natural gas represent the average obtained from the ten greater world producers of these fuels [3];
4. The hydrogen content in the fuels also increases progressively, to become majoritarian in oil and in natural gas, the latter being essentially composed of methane. Hydrogen is then presented as the fuel gas of the future and initiates a new era for humankind;
5. The fuels are being simultaneously used by our society, that is, still today we use wood as an energy resource. However, there has been a specific period in which a certain fuel has dominated the world scene, by being utilized to supply the major amount of energy consumed in the world. This has happened with wood in the dawn of the Industrial Revolution, by 1850; with coal until the moment that the vehicular transportation brought the use of the twentieth century's liquid fuel, by 1930; and with oil in the beginning of the present millennium. Nowadays, we are right in the methane era, as the majoritarian element in natural gas, synthesis gas, shale gas and in biogases, for which the maximum in the world supply is expected to occur by the middle of the twenty first century. An extension of this scenario could be imagined if the methane hydrate, existent in immense amounts on the oceans bottom, would become technical and commercially feasible to be explored. It is worth mentioning that the decline in the use of fossil fuels occurs even though they continue to be available in the amount needed, because environmental driven motivations exist to induce their substitution, enlarging the possibilities for the use of renewable energies. Based on an analysis of the kinetics of evolution of the fuels that have been used in large scale up to the present, it is proposed that the humankind will have its energetic needs essentially supplied by the ultimate and inexhaustible fuel, hydrogen, by 2080. It should be highlighted, though, that the beginning of the hydrogen era will not involve only the direct use of hydrogen, but specially that of compounds that contain it in high density. The hydrogen era also opens opportunity for more efficient use of energy and with smaller environmental impact, letting emerge more sustainable ways of energy exploitation. In addition to that, there will be a very much important change of geopolitical character based on the fact that hydrogen may be produced from very many different raw materials that are available in all countries of the world, contrarily to the very much localized occurrence

of the fossil fuels. This will create an enormous variation regarding the situation experienced during all twentieth century long that also contaminates the beginning of the XXI century, when transnational interventions and tough wrangles for the property and commercialization of oil and gas have been causing irreparable loses to humanity. Way ahead, in subsequent centuries, the advanced understanding of Atom Physics might allow to jump to a new plateau of energy magnitude by taking better profit of the energy contained in atoms and as the result of controlled nuclear reactions among them.

The scientific and technological challenge to reach the hydrogen era is also a great challenge for the materials science and engineering area, for requesting a deep knowledge about raw materials, technological methods and new materials to allow or to facilitate the production, storage and safe use of hydrogen. This theme's being treated by the Materia Journal [5] that emphasizes the invitation for new articles to show new possible paths to be followed

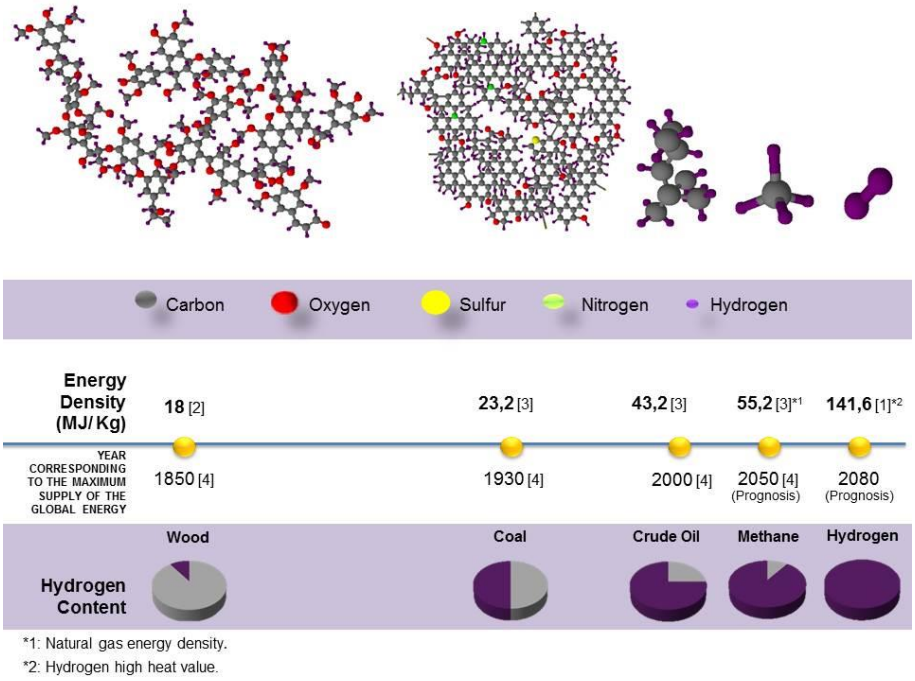

Figure 1: Fuels used by our society since the Industrial Revolution, showing their progressive decarbonization and increase in the hydrogen content and on the energy density, with indications and projections for periods corresponding to world peak utilization.

BIBLIOGRAPHY

[1] GUPTA, R.B., "*Hydrogen Fuel-Production, Transport and Storage*". B. Raton, Fl, USA, CRC Press, Taylor & Francis Group, 2009.

[2] Energy Statistics Manual, INTERNATIONAL ENERGY AGENCY, http://www.iea.org/publications/freepublications/publication/statistics_manual.pdf.

[3] Key World Energy Statistics, INTERNATIONAL ENERGY AGENCY, 2013, http://www.iea.org/publications/freepublications/publication/KeyWorld2013.pdf.

[4] AUSUBEL, J.H., GRUBLER, A., NAKICENOVIC, N., "Carbon Dioxide Emissions in a Methane Economy", *Climatic Change* v. 12, n. 03, pp. 245-63, 1988.

[5] MIRANDA, P.E.V., "Materials to be used in the energy industry", *Matéria*, v. 18, n. 01, 2013.