BACK TO THE BIO-FUTURE

Serge Pérez
Centre de Recherche sur les Macromolécules Végétales, CNRS, Université Joseph Fourier, Grenoble, France.

Less than 300 years of modern industry and modern consumerism will have exhausted fossil resources that have accumulated over 150-200 millions years. Up to the beginning of the 20th century renewable agricultural carbohydrates constituted the raw materials for fuel, chemical and material production. They were gradually replaced by petroleum based derivatives. The depletion of petroleum resources, along with the current concerns about the warming of the planet that can be attributed to human activities, make it urgent to shift dependence away from fossil resources to renewable biomass resources. Sustainable alternatives should be developed commercially in the very near future, both in terms of energy production and commodity products. As for the future energy generation only a multi-faceted approach is likely to provide a viable solution; it will include nuclear, hydroelectricity, solar, hydrogen, wind and biofuel… At the present time, biofuel may be expected to cover a small percentage of the total power that could be generated. The dual goal of producing bio-power and biomaterials, while enhancing the management of greenhouse emissions should be pursued. To this end, the concept of bio-refinery has been proposed, which parallels the petroleum refinery, in the imbalance between transportation fuels and chemical needs. The bio-refinery operates on an abundant renewable raw materials (ligno-cellulosic, polysaccharides,….) which are fractionated, through a series of processes, and further converted into commodity chemical molecules and transportation fuels. In order for the bio-refinery to be effective, significant and concomitant advances in genetics, “green” and “white” biotechnologies, process chemistry and engineering should be pursued. This would lead, among others, to significant changes in agronomical practices with innovation in plant resources. The imbalance between food / non food utilization of these agro-resources should be a major and constant concern. The integration of biosciences with engineering principles is leading to the development of biochemical engineering. The contribution of plant biologists, carbohydrate chemists and process engineers to the implementation of the bio-refinery is likely to be essential. The parallel between petroleum refinery and bio-refinery provides reasonable foundation for the economical realism of this concept. It is nevertheless obvious that other concepts such as those embedded into the “*Green Chemistry*” principles will be incorporated within the new manufacturing paradigm. The mere fractionation of abundant biosynthesized raw materials is far from having the adhesion of all the scientific community; alternative concepts to the bio-refinery concept are also emerging. It is advocated that the depletion of petroleum resources is unavoidable within the next half century or more, but that about 5% of the total petroleum output from a conventional refinery goes to chemical products. This means that the current resources are more than adequate to fill the chemical industry for many more years. Bio-processing will dominate over chemical processing only by improving its capital, operating cost requirement, and bringing added-values and innovation. This can be performed based on the “intelligent” use of the unique bio-molecular and bio-macromolecular architectures that are derived from biosynthetic pathways and that are not attainable throughout thermodynamically driven processes. Our most recent knowledge about the different levels of structural organizations are providing rational ways of conducting chemical modifications while keeping the biodegradable and recyclable features of the starting raw material. Exploring these new frontiers, far from the concept of “replacement”, is likely to stimulate the whole carbohydrate community that can incorporate sophisticated synthetic methodology, glycobiology, plant polysaccharides and plant sciences to help shifting society’s dependence away from petroleum to renewable biomass resources.