Interdisciplinary Biotechnological Advances

Maria del Pilar Rodriguez-Torres
Claudia Martinez-Alonso *Editors*

Biotechnology in the generation of biofuels

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Interdisciplinary Biotechnological Advances

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Preface

Nowadays, the necessity for alternative energy sources has led to an increase in the research on topics such as solar, wind, geothermal energies and the like as well as of biomass. The biomass concept refers to renewable organic materials coming from plants and animals, and it is also fundamental when it comes to biofuels because it must be transformed in order to obtain them. The procedures to do this are mainly chemistry-based that can be tailored by including or adapting biotechnology.

This book, *Biotechnology in the Generation of Biofuels*, is intended to be introductory to the general outlook on biomass and biofuels starting from what they are, the different generations they are subdivided into, and the procedures used in general as well as with biotechnological interventions; hence, the reader can get the whole picture on the relevance and urge to make biofuels much more available as time passes by given the fact that fossil fuels are on the verge of disappearing as shown by yearly statistics worldwide. Additionally, advantages and disadvantages of biofuels are presented as well as information on LCAs, policies in some countries, professional opportunities, and support information on biotechnological methods to produce biofuels.

We think this volume can be quite useful to academia students and professors and people involved in industry or government, particularly because they are part of the whole assembly necessary for the development, fabrication, industry-scaling, and policy-making necessary for a smooth and gradual transition to the renewables domain.

We, the editors, thank all the authors who contributed to this book as well as Dr. Jayanta Kumar Patra, who besides, granted us the opportunity to participate in this project and aided with valuable comments and part of the edition.

The editors wish to thank Sudha Ramachandran for her support and professionalism during all the phases in the book processing as well as Haridharini Velayoudame for her intervention in the last production stage.

Dr. Martinez Alonso wishes to thank her husband and daughter for their support throughout the months the book was in its writing process and, also wants to dedicate the volume in memory of Dr. Victor Manuel Dominguez Marquez (Autonomous University of Guerrero @Iguala, Gro.).

Boulevard Juriquilla, Querétaro, Mexico Maria del Pilar Rodriguez-Torres
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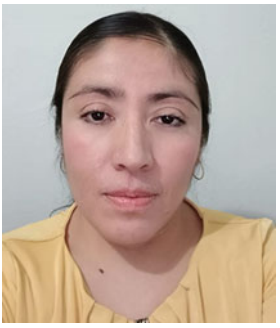
About the Editors

Maria del Pilar Rodriguez-Torres is a Physics Engineer (UASLP), who got her PhD degree in Optics from the Center of Research in Optics (Leon, Guanajuato, Mexico) and has been a postdoctoral researcher at ENES Leon UNAM and CFATA UNAM. Her field of study is nanomaterials synthesis aimed at biological applications and their characterization; she is also interested in renewable energies, food science, outreach, and programming and has authored 20 publications among research articles, reviews, manuals, and book chapters. She has lectured undergraduate and graduate students from different areas (Dentistry, Physiotherapy, Technology) and participated as a referee for the RSC Advances, the Journal of Molecular Sciences and Materials Views journals.



Claudia Martinez-Alonso is currently a Professor at the Faculty of Agricultural and Environmental Sciences, Autonomous University of Guerrero. She obtained her BSc degree in Chemistry at the Autonomous University of the State of Morelos (UAEMor) and pursued her Energy Engineering postgraduate studies at the Renewable Energies Institute of the National Autonomous University of Mexico. She has been a postdoctoral fellow in the renewable energies field at the National Autonomous University of Queretaro and has published 15 scientific articles on nanostructured materials and

their applications for energy storage and use. She has mentored and graduated 1 postgraduate and 3 undergraduate students. Her scientific expertise is focused on non-toxic nanostructures for diverse applications and the efficient use of renewable energies.

Introduction

Evelyn B. Díaz-Cruz, Jayanta Kumar Patra, Claudia Martinez-Alonso, and Maria del Pilar Rodriguez-Torres

I think the biggest innovations of the twenty-first century will be at the intersection of biology and technology. A new era is beginning.

Steve Jobs (February 1955–October 2011)

Abstract This introductory chapter will present brief and elemental information, concepts as well as a summary of the general aspects that are related to the production of biofuels by means of the traditional methods and the biotechnology-based ones. Also, topics related to environmental impact like greenhouse gases (GHG), the depletion of fossil fuels, the evaluation of biofuels regarding their environmental issues, biofuels that are already in use, and necessary policies for biofuels implementations are covered. The aforementioned elements are relevant because as it happens with novel discoveries and technologies, risks and advantages must be taken into consideration. We want to clarify, too, that the book content is an effort, especially for the neophyte reader to visualize, in the first place a general overview on biofuels in a sequential manner that includes how they are defined and what the concepts such as biomass and feedstock refer to. Latterly, the role of

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biotechnology starting with its basic definition and subdivisions is addressed along with the four generations of biofuels, from which, the third and fourth ones are related to biotechnology because of the tools they make use of like genetic engineering. It has to be noted, that at this time, solely biotechnology-based biofuels are not being implemented in the real world. They are being investigated and under development in research environments since proper biotechnological techniques are not used yet commercially but thermochemical or physical approaches. Even so, chapters on biofuels obtained by traditional methodologies have been written for further reference, for example, about pyrolysis and some of its subcategories, transesterification, and the like and then, including whenever possible wholly-based biotechnology methodologies to give support on these potential and benign processes. Therefore, this volume was done with the purpose of transporting readers from the established techniques to manufacture biofuels to the ones that are in the works and related directly to biotechnology, that have not have reached a scaled-up capacity yet, but that have an outstanding potential considering that relying completely on feedstock such as crops may not be the best option at the end of the day because of the risk associated to the costs competition between food production/supply and biofuels manufacturing. This mainly includes the involvement of microorganisms as certain types of micro- and macroalgae. In the last chapter, conclusions are presented, future perspectives are given and even some discussions on industry global collaborations are mentioned with the intention of giving the book a frame of reference on the biofuels subject.

Keywords GHG · Biotechnology · Biofuels · Biomass

1 Insights

1.1 Energy and its Worldwide Exploitation

Climate change is one of the most serious problems humanity is facing nowadays. In 2006, Al Gore warned of a growing "planetary emergency" if global warming continued unchecked, including rising sea levels, coastal flooding, and climate refugee nations (Manuel 2017). The effects mentioned 15 years ago are evident today, with the increase in the average temperature of the planet even in zones that tend to be cold, the change in rainfall patterns which derives in floods in some cases, the increase in sea level, land exhaustion, and the frequency of extreme meteorological phenomena is confirming this argument and putting our model of life to the test, which will have to adapt to new climatic, social, and economic conditions. The most important cause of climate change is the warming of the planet, produced by the so-called Greenhouse Gases (GHG) and which are currently emitted in the industrial, agricultural, transport, and energy consumption processes that the current generated development model entails by human activity, even household activities such as the use of aerosols provoke environmental damage. The GHG layer, located in the lower area of the atmosphere, lets long-wave solar radiation pass toward the

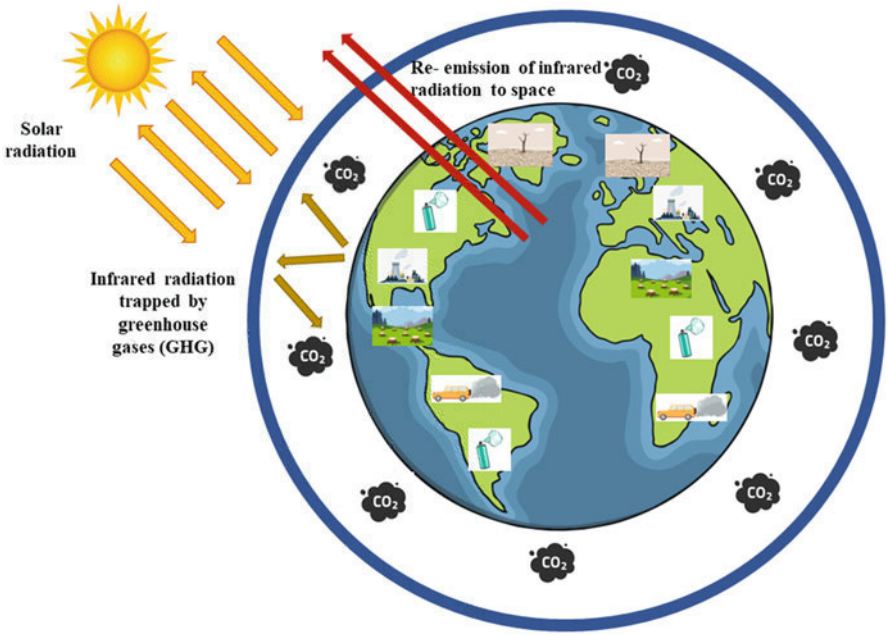

Fig. 1 Greenhouse effect

Earth's surface, which then heats up. However, when this heat is emitted back into the atmosphere, GHG do not let it escape and retain it, causing the planet to warm (Khanna et al. 2011). Figure 1 shows graphically how such a process occurs with GHG in the form of CO_2 (black clouds in the figure) emissions and depicting some of the polluting interventions that cause this.

The global energy demand has been increasing in a great manner throughout the last decades and it is expected that the tendency continues exponentially. This is greatly due to the increase in population which, in turn, contributes to the demand for all kinds of products and therefore leading to industrial growth (Zohuri 2020). Consequently, the need for alternative sources of energy that can potentially, in the beginning, if not suppress completely GHG, at least, be a barrier to their excess is a must. Furthermore, another factor to consider is the depletion of fossil resources, from which basically a great number of fuels come, e.g., gasoline, diesel, and natural gas. There are, additionally, other general issues such as supply security, and climate change problems; for which renewable energies in the form of biofuels represent a solution (Moriarty and Honnery 2016). Renewable energies are classified as wind, solar, geothermal, biomass, among others (Dogaru 2020). Biomass is a promising alternative instead of the raw materials used to produce fossil fuels and it constitutes the core of biofuel generation. One thing to clear out is that the concepts of biomass and feedstock are not far apart. Biomass is defined as a renewable organic material that comes from plants and animals whereas feedstock is a general term that refers to

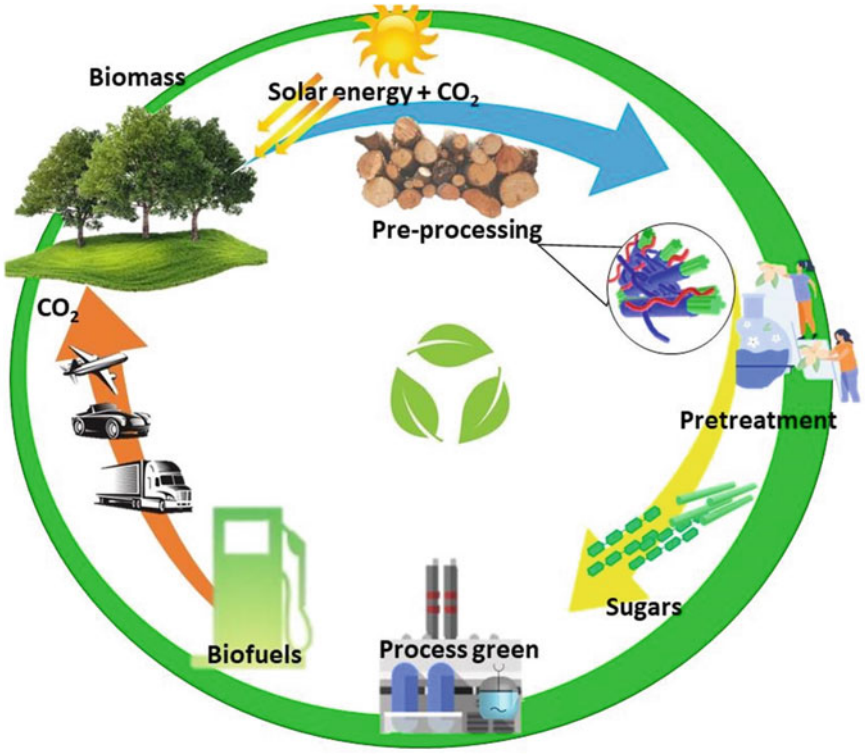

Fig. 2 Biomass processing

a material that is used to make fuels. In fact, they can be used interchangeably or even together, e.g., biomass feedstock (Bioenergy Technologies Office).

The conversion of biomass feedstocks into biofuels can be considered to some extent as a predominantly environmental friendly process, although that does not remove its industrial character totally. So is the use of biofuels for transportation. When we use bioethanol instead of gasoline, we help reduce atmospheric CO_2 in three ways: first, we avoid the emissions associated with gasoline; second, we allow the CO_2 content of fossil fuels to remain in storage; and third we provide a mechanism for CO_2 absorption by growing new biomass for fuels. Due to their compatibility with the natural carbon cycle, biofuels offer the most beneficial alternative to reduce greenhouse gases in the transport sector, as shown in Fig. 2 (Khanna et al. 2011).

2 Renewable Energies and Their Relevance in Sustainability

Renewable energies also known to be clean and are defined as those that come from natural sources or processes that are constantly replenished. For example, sunlight or wind just to mention the most acknowledged ones. On the other hand, sustainability refers, in environmental terms, to the preservation of natural resources. However, there is a huge debate on whether renewable energies (usually generated from renewable resources) and sustainability go hand in hand, particularly considering that if the rate of use exceeds the rate of renewal, that is, the source is used more than its recreation, it may become unsustainable at some point. Despite this, interest in renewable energies has been sparking interest in many levels, scientific, political, and from the general public, since a long time ago (Owusu and Asumadu-Sarkodie 2016). And they have become an attention focus because of fossil fuels depletion in the long run.

Another aspect to take into consideration is that the use of renewable energy sources and sustainable development are two variables that are closely related with each other because renewable energy resources appear to be the one of the most efficient and effective solutions to the current environmental problems, too, and not only to the depletion of nonrenewable resources (Dincer 2000). The difficulties that renewable energies implementation are facing have to do with the economy, mostly, for example, the solar industry employs more people than the one related to coal. Also, large-scale renewable energy projects require large amounts of capital to run and the lack of policies as well as regulations makes it difficult to minimize associated risks. In addition to this, the absence of infrastructure for distribution and trained personnel to work on it is slowing this advance, too.

There are also numerous life cycle assessment (LCA). LCAs are defined as systematic analyses about the environment during the whole life cycle of a product, material, process, or other measurable activities. These studies when it comes to biofuels take account of the climate change and other of their environmental impact factors. They are continuously published every year since a long time ago and, the main aspect that has been reported regarding biofuels is the achievement of the decrease in life cycle GHG emissions using the estimation of their potential repercussion on climate change, which is currently an issue of urgency. Nonetheless, their findings are often limited and inconsistent because they consider not global but very specific features, for instance, region, feedstock/biomass or biofuel kind (Jeswani et al. 2020). In addition to this, scientific literature is focused on too individual aspects in the same fashion as LCAs but more engaged to research on biomass/feedstock types and procedures to handle it, methodologies to produce biofuels, and so on. In like manner, some more details can be found on biofuels from government agencies, non-governmental organizations (NGOs) energy sector companies, but it is quite scarce (facts, statistics, initiatives, news on uses of some biofuels, and so forth). As a consequence, it is not likely that at this moment, a definite consensus on the real impact of biofuels can be achieved due to this information dispersion.