Luís Eduardo Pimentel Real

Recycled Materials for Construction Applications

Plastic Products and Composites

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Preface

In this work, a general approach to the recyclability of plastics and composites used in construction, with the purpose of their reuse, is provided.

The various recycling technologies applicable to plastic materials, most used in civil construction, are described, indicating the difficulties inherent to these processes for the main polymers. In this context, several illustrative cases of success and examples of recent technological innovation are presented.

It also addresses the issue of quality control, certification, and standardization adopted in Europe for recycled plastics.

Several market data are presented, namely the production capacity for plastics and bio-based polymers, the quantities of recycled plastic and, for each type of polymer, some statistical data on recycling. The obstacles for recycled materials in the plastics market are mentioned, also referring to the variables that most influence recycling costs and the price of recycled materials.

The conclusions drawn from this work are of several types. In a succinct way, they demonstrate that recycling is a fundamental resource to minimize waste and reduce environmental pollution, constituting a strategic approach to the management of waste from plastic construction products at the end of its useful life.

The main challenges and future perspectives arising from the most recent developments in this area are presented.

Finally, the most relevant strategic recommendations are presented in order to continue and concretize the resolution of the problem of recycling plastics and seek to achieve the objectives of the circular economy, which involves the development of a specialized market for recycling and recycled plastics, and, consequently, promote the purchase and sale operations of economic agents and interested parties (i.e., sellers, buyers, consumers, associations, recyclers, and manufacturers of production machinery) in order to also increase the recycling and recyclability of plastic waste.

Lisbon, Portugal — Luís Eduardo Pimentel Real

Introduction

The purpose of this work is to present the state of the art on the topic "recycling of plastic building materials," comprising a synthetic market analysis, presenting the latest developments in plastics recycling technologies, and making some recommendations to optimize the success of recycling and encourage the circular economy.

In Chap. 1, the problem is briefly described and the topic of plastics sustainability is addressed, covering the topic of life cycle analysis and some case studies related to plastic materials.

Then, in Chap. 2, the various types of plastics and additives usually incorporated in polymers are described.

Chapters 3 describes the use, in construction, of various types of plastic materials, including composites, biocomposites, and recycled plastics.

Next, in Chap. 4, the entire value chain for plastic waste is described, from the collection to the introduction of recycled materials on the market, with an emphasis on separation and recycling technologies, including recycling machinery. This chapter also addresses several aspects related to the quality of recycled plastics, including influencing factors and constraints, ending with a description of the various recycling processes.

Chapter 5 summarizes data statistics on the plastics, starting with the evolution of production capacity of plastic materials, followed by recycled plastics, referring economical topics like costs of recycling and prices of recyclates.

In Chap. 6, the main constraints and difficulties associated with the market of recycled plastic materials are mentioned.

Next, in Chap. 7, the recycling of the main plastics used in construction is described and success stories are presented regarding the recycling of each type of polymer.

Finally, Chap. 8 presents the conclusions, the challenges that are expected for the future in the short and medium term, and the recommendations to guarantee the success of recycling and encourage the circular economy.

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About the Author

Luís Eduardo Pimentel Real Graduated in chemical engineering at the Instituto Superior Técnico (IST), Lisbon, Portugal. Holds a PhD in chemical engineering (IST, Portugal) and a PhD in chemistry (UBP, France). He worked in the Materials Department of National Laboratory of Civil Engineering (LNEC) from 1990 until 2015. Since January 2016, has been working in the Buildings Department of LNEC. Its activity has been very dispersed and covers several fields, namely applied chemistry, degradation and stabilization of polymers, durability, environmental issues (radon and recycling), biocomposites, assessment of construction products, and technical advice. He is author and co-author of more than 200 publications, including scientific papers in journals listed on the ISI WEB of Science, communications at international scientific meetings, and technical guides and reports, and has participated in several European research projects, and in specialized courses and technical training. He was responsible, for several years, for an accredited laboratory of plastics and composites. He was awarded the degree of specialist in metrology by the Portuguese Order of Engineers, for having carried out numerous activities in the scope of quality control of plastic materials and products, doing agreement activity and support for certification, technical auditing in plastic pipe factories located in Portugal and Europe, and participation in technical committees and working groups.

List of Abbreviations and Acronyms

ABP	abiotic depletion parameter (for LCA)
ABS	poly (acrylonitrile butadiene styrene)
AP	acidification parameter (for LCA)
Bio-PBS	biobased poly(butylene succinate)
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CH_4	methane
C_2H_2	acetylene
C_2H_4	ethylene
CFC	chlorofluorocarbon
CIS	Commonwealth of Independent States
CO	carbon monoxide
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
CPR	regulation of construction products
DEHP	Bis (2-ethylhexyl) phthalate
DIS	Draft International Standards
DNA	deoxyribonucleic acid
EC	European Commission
ECHA	European Chemical Agency
ELV	low voltage equipment
EP	eutrophication parameter (in ACL)
EPPA	European PVC Window Profile and Related Building Products Association
EPS	expanded polystyrene
EU	European Union
FDIS	Final Draft International Standard
FprEN	draft European Standard for Formal Vote
FRC or FRP	fiber-reinforced composites / plastics
FTIRS	Fourier-transform infrared spectroscopy
GHG	greenhouse gases

GRP	polymer/glass fiber reinforced plastic
Gt	gigatonnes
GWP	global warming parameter (in LCA)
H_2	molecular hydrogen
HBP	hydro-biodegradable plastics
HCN	hydrocyanic acid
HDPE	high-density polyethylene
HIPS	improved impact resistance polystyrene
HSI	hyperspectral imaging system
HTP	human toxicity parameter (in LCA)
ISCC	International Sustainability & Carbon Certification system
ISO	International Organization for Standardization
LCA	life cycle analysis
LDH	double layered hydroxide
LDPE	low-density polyethylene
LLDPE	linear low-density polyethylene
LIBS	laser-induced breakdown spectroscopy
MIR	mid-infrared
MIR-HSI	mid-infrared hyperspectral imaging system
Mt	megatonnes
N	nitrogen
NAFTA	North American Free Trade Agreement (North American Free Trade Agreement, involving Canada, Mexico, and the United States, replaced by the USMCA on July 1, 2020)
NFC	cellulose nanofiber
NH_3	ammonia
NIRS	near infrared spectroscopy
NO	nitrogen monoxide
NOx	nitrogen oxides
O_2	molecular oxygen
OBP	oxy-biodegradable plastic
OLDP	ozone depletion parameter (in LCA)
P	phosphorus
PA	polyamide (or nylon)
PAc	polyacrylate
PB	polybutadiene or polybutylene
PBAT	poly(butylene adipate terephthalate)
PBT	polybutylene terephthalate
PC	polycarbonate
PCL	polycaprolactone
PCR	post-consumer recycled
PE	polyethylene
PET	polyethylene terephthalate
PHA	polyhydroxyalkanoate
PHB	polyhydroxybutyrate