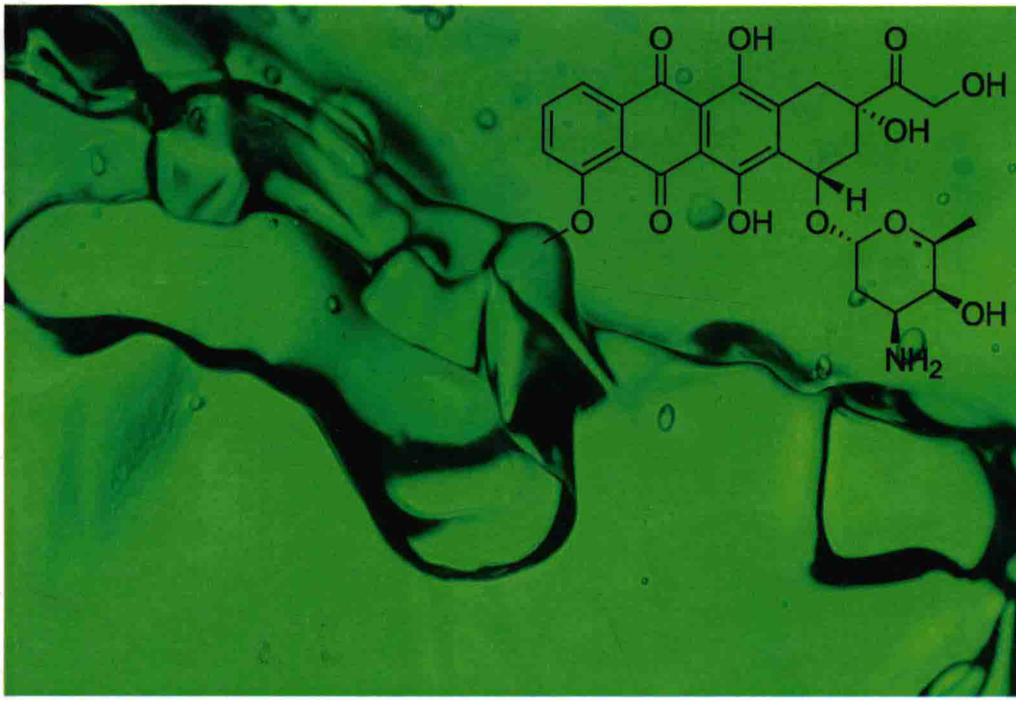
Chemical Technology

Key Developments in Applied Chemistry, Biochemistry and Materials Science



Editors
Nekane Guarrotxena, PhD
Gennady E. Zaikov, DSc
A. K. Haghi, PhD

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Edited by
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LIST OF CONTRIBUTORS

O. M. Alekseeva
Emanuel Institute of Biochemical Physics, Russian Academy of Sciences, Moscow 119334, Email: olgavek@yandex.ru

Sogrina Darya Alexandrovna
Moscow State University of Food Production, 11 Volokolamskoe Shauosse, Moscow 125080, Russia

D. S. Andreev
Volgograd Architectural University Sebryakovsky Branch

M. Arabani
Professor, Faculty of Engineering, University of Guilan, Rasht 3756, Iran, Email: arabani@guilan.ac.ir

V. A., Babkin
Volgograd Architectural University Sebryakovsky Branch, Email: Babkin_v.a@mail.ru

Bakr Mona
The National Institute for Laser Enhanced Sciences, Cairo University, Egypt

A. A. Belov
University of Chemical Technology of Russia (RChTU) him. D. I. Mendeleev, ch. Biotechnologies, Research Institute of Textile Materials, Moscow, Russian Federation, Email: ABelov2004@ yandex.ru

Samarth Bhatt
Jena University Hospital, Friedrich Schiller University, Institute of Human Genetics, Kollegiengasse 10, D-07743 Jena, Germany.

V. I. Binyukov
N. M. Emanuel Institute of Biochemical Physics, Russian Academy of Sciences, ul. Kosygina 4, 119334 Moscow, Russian Federation. Fax (7-495) 137 41 01, tel. (7-495) 939 71 40

S. B. Bokieva
M. V. Lomonosov MSU, Biological Faculty, Leninskie Gory, 119991 Moscow, Russia

S. N. Bondarenko
Volzhsky Polytechnical Institute, branch of Federal State Budgetary Educational Institution of Higher Professional Education, Volgograd State Technical University, 42a Engels Str., 404121, Volzhsky, Volgograd Region, Russia

E. B. Burlakova
Emanuel Institute of Biochemical Physics RAS, 119334, Kosygina str., 4, Moscow, Russia

N. I. Chekunaev
Semenov Institute of Chemical Physics, Russian Academy of Sciences (RAS), Ul. Kosygina, 4, Moscow, 119991, Russia. nichek@mail.ru

M. S. Chirikova
Institute of Microbiology, National Academy of Sciences, Belarus, 220141, Kuprevich str.2, Minsk, Belarus, E-mail: margarita.chirikova@mail.ru, fax: +375(17) 267-47-66

Tarek A. El-Tayeb
The National Institute for Laser Enhanced Sciences, Cairo University, Egypt

Vladimir S. Feofanov,
N. M. Emanuel Institute of Biochemical Physics of the Russian Academy of Sciencesv, Kosygin st. 4, 117977 Moscow, Russia

Sergey N. Gaydamaka
Department Chemical Enzymology, Chemistry Faculty, Moscow State University, Leninskye Gory, 1, build.11, Moscow,119992, Russia, Phone: +7(495) 939-5083, Fax: + 7 (495) 939-5417, e-mail: s.gaidamaka@gmail.com

Sergey Gaydamaka
Murygina Lomonosov Moscow State University, Chemistry Faculty, Department of Chemical Enzymology. 119991, Moscow, Leninsky gory 1/11, fax: +7-495-939-54-17., e-mail: s.gaidamaka@gmail.com

N. Yu. Gerasimov
Emanuel Institute of Biochemical Physics RAS, 119334, Kosygina str., 4, Moscow, Russia, e-mail: n.yu.gerasimov@gmail.com

M. D. Goldfein
Saratov State University named after N.G. Chernyshevsky, Russia, goldfeinmd@mail.ru
A. N. Goloshchapov
Emanuel Institute of Biochemical Physics RAS, 119334, Kosygina str., 4, Moscow, Russia

Iman E. Gomaa
German University in Cairo (GUC), Main Entrance of Al-Tagamoa Al-Khames, New Cairo City, P.O. 11835, Egypt, German University in Cairo, Egypt, iman.gomaa@guc.edu.eg

N. A. Grebenkina
Higher Chemical College, RAS, Miusskaya sq., 9 Moscow, 125047

K. Z. Gumargalieva
N. N. Semenov Institute of Chemical Physics, RAS, 4 Kosygin Street, Moscow, 119334, Russia

A. K. Haghi
Faculty of Engineering, University of Guilan, Rasht, Postal code: 3756, I. R. Iran. Tel: +98(131)6690270, Fax: +98 (131) 6690270. Email:Haghi@guilan.ac.ir

A. N. Inozemtsev
M. V. Lomonosov MSU, Biological Faculty, Leninskie Gory, 119991 Moscow, Russia

V. F. Kablov
Volzhsky Polytechnical Institute (branch) Volgograd State Technical University, 42a Engelsa Street, Volzhsky, Volgograd Region, 404121, Russian Federation, E-mail: vtp@volpi.ru; www.volpi.ru

A. M. Kaplan
Semenov Institute of Chemical Physics, Russian Academy of Sciences (RAS), Ul. Kosygina, 4, Moscow, 119991, Russia.

O. V. Karpukhina
N. N. Semenov Institute of Chemical Physics, RAS, 4 Kosygin Street, E-mail: olgakarp@newmail.ru

V. V. Kasparov
Emanuel Institute of Biochemical Physics RAS, 119334, Kosygina str., 4, Moscow, Russia

N. A. Keibal
Volzhsky Polytechnical Institute (branch) Volgograd State Technical University, 42a Engelsa Street, Volzhsky, Volgograd Region, 404121, Russian Federation, E-mail: vtp@volpi.ru ; www.volpi.ru

Yu. A. Kim
Institute of Cell Biophysics, Russian Academy of Sciences, Pushchino, Moscow region

Lubov Kh Komissarova
N. M. Emanuel Institute of Biochemical Physics of the Russian Academy of Sciences, Kosygin st. 4 117977 Moscow, Russia. e-mail: chembio@sky.chph.ras.ru, e-mail komissarova–lkh@mail.ru, Telephones: 8(495)9361745(office), 8(906)7544974(mobile), Fax: (495)1374101

A. I. Korotaeva
University of Chemical Technology of Russia (RChTU) him. D.I.Mendeleev, ch. Biotechnologies, Research Institute of Textile Materials, Moscow, Russian Federation

A. L., Kovarskij
Emanuel Institute of Biochemical Physics RAS, 119334, Kosygina str., 4, Moscow, Russia

T. V. Krekaleva
Volzhsky Polytechnical Institute (branch) Volgograd State Technical University, 42a Engelsa Street, Volzhsky, Volgograd Region, 404121, Russian Federation, E-mail: vtp@volpi.ru ; www.volpi.ru

Thomas Liehr
Jena University Hospital, Friedrich Schiller University, Institute of Human Genetics, Kollegiengasse 10, D-07743 Jena, Germany

E. I., Martirosova
Emanuel Institute of Biochemical Physics, RAS Kosygina st., 4 Moscow, 119334, e-mail: ms_martins@mail.ru

L. I. Matienko
N. M. Emanuel Institute of Biochemical Physics, Russian Academy of Sciences, ul. Kosygina 4, 119334 Moscow, Russian Federation. Fax (7-495) 137 41 01, tel. (7-495) 939 71 40, e-mail: matienko@sky.chph.ras.ru

L. A. Mosolova
N. M. Emanuel Institute of Biochemical Physics, Russian Academy of Sciences, ul. Kosygina 4, 119334 Moscow, Russian Federation. Fax (7-495) 137 41 01, tel. (7-495) 939 71 40,

Valentina P. Murygina
Department Chemical Enzymology, Chemistry Faculty, Moscow State University, Leninskye Gory, 1, build.11, Moscow,119992, Russia, Phone: +7(495) 939-5083, Fax: + 7 (495) 939-5417, e-mail: vp_murygina@mail.ru, vpm@enzyme.chem.msu.ru

O. V. Nevrova
Emanuel Institute of Biochemical Physics RAS, 119334, Kosygina str., 4, Moscow, Russia

B. K. Novosadov
V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, 119991 Moscow, Kosygina str., 19, Russian Federation, e-mail: bk.novosadov@mail.ru

I. G. Plashchina
Emanuel Institute of Biochemical Physics, RAS Kosygina st., 4 Moscow, 119334

D. A. Provotorova
Volzhsky Polytechnical Institute, branch of Federal State Budgetary Educational Institution of Higher Professional Education Volgograd State Technical University, 42a Engels Str., 404121, Volzhsky, Volgograd Region, Russia

E. A. Raspopova
University of Chemical Technology of Russia (RChTU) him. D.I.Mendeleev, ch. Biotechnologies, Research Institute of Textile Materials, Moscow, Russian Federation

G. K. Rossieva
Volgograd Architectural University Sebryakovsky branch

E. G. Rozantsev
Saratov State University named after N.G. Chernyshevsky, Russia

A. S. Samsonova
Institute of Microbiology, National Academy of Sciences, Belarus, 220141, Kuprevich str.2, Minsk, Belarus

T. P. Shakun
Institute of Microbiology, National Academy of Sciences, Belarus, 220141, Kuprevich str.2, Minsk, Belarus

A. G. Stepanova
Volzhsky Polytechnical Institute (branch) Volgograd State Technical University, 42a Engelsa Street, Volzhsky, Volgograd Region, 404121, Russian Federation, E-mail: vtp@volpi.ru ; www.volpi.ru

R. Tanzadeh
Department of Civil Engineering.University of Guilan, Rasht, Iran.Tel: +98(131)3229883, Fax: +98 (131) 3231116. Email: rashidtanzadeh@yahoo.com

P. Valentina
Murygina Lomonosov Moscow State University, Chemistry Faculty, Department of Chemical Enzymology. 119991, Moscow, Leninsky gory 1/11, fax: +7-495-939-54-17.

Ananiev Vladimir Vladimirovich
Moscow State University of Food Production, 11 Volokolamskoe shauosse, 125080, Moscow, Russia, kaf.vms@rambler.ru

G.E. Zaikov
N. M. Emanuel Institute of Biochemical Physics, Russian Academy of Sciences, ul. Kosygina 4, 119334 Moscow, Russian Federation. Fax (7-495) 13741 01, tel. (7-495) 939 71 40,-mail: chembio@sky.chph.ras.ru

A. Zhivaev
Volzhsky Polytechnical Institute (branch) Volgograd State Technical University, 42a Engelsa Street, Volzhsky, Volgograd Region, 404121, Russian Federation, E-mail: vtp@volpi.ru ; www.volpi.ru

LIST OF ABBREVIATIONS

AP	acetophenone
AHB	alkylhydroxybenzenes
AR	alkylresorcinols
AC	asphalt concrete
AFM	atomic force microscopy
BNCT	boron neutron capture of tumor therapy
BSA	bovine serum albumin
CNTs	carbon nanotubes
COD	chemical oxygen demand
CNR	chlorinated natural rubber
CMC	critical micelle concentration
DAAD	deutsche akademische austausch dienst
DAC	dialdehydecellulose
DP	diamond pore
DSC	differential scanning calorimeter
DNSA	dinitrosalicylic acid
DSB	double strand breaks
DM	dressing materials
EMEM	eagle's minimal essential medium
EPR	electron paramagnetic resonance
ETP	electron transport particles
ERKs	extracellular signal-regulated kinases
GC	gas chromatograph
GCMD	grand canonical molecular dynamics
GCMC	grand canonical monte carlo
HMPA	hexamethylphosphorotriamide
HR	hexylresorcinol
HMS	high melt strength
HCO	hydrocarbon oxidizing cells
ISCN	international system for human cytogenetic nomenclature
IUPAC	international union of pure and applied chemistry

LED	light emitting diode
LMWC	low molecular weight chitosans
MSD	mean-square displacement
MFI	melt flow index
MPC	methylphenylcarbinol
MR	methylresorcinol
MF	microfiltration
MD	molecular dynamics
MWCO	molecular weight cut-off
MC	monte carlo
MWNT	multi-walled carbon nanotube
NF	nanofiltration
NILES	National Institute of Laser Enhanced Sciences
NCT	neutron capture therapy
NDT	nottingham device test
PEH	phenyl ethyl hydroperoxide
PB	phosphate buffer
PBS	phosphate buffer saline
PTT	photo thermal therapy
PCN	polymer–clay nanocomposites
PP	polypropylene
RESPA	reference system propagator algorithm
RO	reverse osmosis
SEM	scanning electron microscope
SSB	single strand breaks
SWNTs	single-walled carbon nanotubes
SEM	standard error of the mean
SP	straight path
SBS	styrene–butadiene–styrene
TMC	thermomechanical curves
TFOT	thin film oven test
TEM	transmission electron microscopic
UF	ultrafiltration
VACF	velocity autocorrelation function
ZP	zigzag path

LIST OF SYMBOLS

ρ	material density
D_S^*	preexponential factor
A	difference between titration results in test and control samples
A	new generated area at crack penetration
a_S	crack radius
B	concentration of enzyme solution sample
C and n	material parameters
E	modulus of elasticity
L	membrane thickness
LC	lipolytic activity
m	electron rest mass
$m1$	mass of weighing bottle
$m2$	net bottle weight
T	alkali titer
V	volume of analyzed sample
$V1$	extract aliquot volume
$V2$	volume of graduated flask
v_m	limiting crack velocity
$x1$	total concentration of substances

PREFACE

This collection presents to the reader a broad spectrum of chapters in the various branches of industrial chemistry, biochemistry, and materials science which demonstrate key developments in these rapidly changing fields.

This book offers a valuable overview and myriad details on current chemical processes, products, and practices. The book serves a spectrum of individuals, from those who are directly involved in the chemical industry to others in related industries and activities. It provides not only the underlying science and technology for important industry sectors, but also broad coverage of critical supporting topics.

This new book:

- is a collection of chapters that highlight some important areas of current interest in industrial chemistry, biochemistry, and materials science
- focuses on topics with more advanced methods
- emphasizes precise mathematical development and actual experimental details
- analyzes theories to formulate and prove the physicochemical principles
- provides an up-to-date and thorough exposition of the present state-of-the-art complex materials
- familiarizes the reader with new aspects of the techniques used in the examination of polymers, including chemical, physicochemical, and purely physical methods of examination
- describes the types of techniques now available to the chemist and technician and discusses their capabilities, limitations, and applications

CONTENTS

CHAPTER 1

THE USE OF ULTRASOUND FOR FOAMING OF POLYPROPYLENE

ANANIEV VLADIMIR VLADIMIROVICH and
SOGRINA DARYA ALEXANDROVNA

CONTENTS

1.1 INTRODUCTION

Wide application of polymeric foamed materials, based on the polyolefin's, explained by their mechanical, insulating, and operational properties. Foamed polypropylene (PP) is widely used material in numerous applications. Foamed PP products are highly demanded in automobile production, construction; some of them are used as a cushioning materials and weight reducers in complex structures. There are some practically used manufacturing technologies to produce foamed PP. But all of them have some general disadvantages. All of them are very complex and, hence, this technologies are expensive, making PP foam more costly them other foamed polyolefins. Frequently, foaming of PP requires the use of specific blowing agents, specific types of polymer, and special process conditions [1].

Analysis of the literature data has shown that significant impact on technological and operational properties of the polymer products renders ultrasonic treatment during their production [2–4]. With the changes occurring in polymers under sonication, we assume that using of ultrasonic irradiation may be promising for the foaming processes. Moreover, we presuppose that ultrasonic treatment during extrusion of polymer foam can change structure (size of cells, cells distribution in the material volume) of foamed PP and by that change bulk density of foamed materials.

1.2 EXPERIMENTAL PART

Russian PP grade 21020, azodicarbonamide and Hydrocerol BM 70, as blowing agent, have been chosen for foaming. Usually, specially designed PP grades are used for foaming processes. All of them have high branching and long side chains of their macromolecules. It is considered that such polymer structure provides high melt strength (HMS) of this PP grades (over six times higher than traditional PP grades). We thought it best to use Russian PP grades, to illustrate the benefits of the use of ultrasound in the foaming process. Therefore, we chose a PP grade with the same rheological characteristics as special grades with HMS (melt flow index of used PP = 2 g/10 min).

The blowing agent, Hydrocerol BM 70, is injected in amounts from 0.1 wt % to 1.5 wt % of the composition. According to current technology chemical blowing agents on the basic of azodicarbonamides injects into composition in quantity 0.5 wt %–1 wt %, and 5 wt %. We assumed that the use of ultrasound in the extrusion process can improve the gassing in the polymer matrix. So, we decided to decrease the concentration of the blowing agent to 0.1 wt %.

Prerequisite for such solutions were previously conducted experiments in which we observed a significant reduction in the melt viscosity of PP, which was measured directly during the extrusion process. It is suggested in literature date, that significant pressure changes may occur in these areas. Moreover, a significant increase in temperature can take place in the zones of small volume. We assumed that these zones, arising from the inhomogeneity of the melt, may play a role of nucleators. The sharp reduction in pressure in these areas will promote growth of gas bubbles.

Selection of blowing agent explains that it is easy to blend them with polymer, and also temperature decomposition range of azodicarbonamide corresponds to the processing temperature of PP. Azodicarbonamide decomposes with allocation of of nitrogen at the temperature about 170°C.

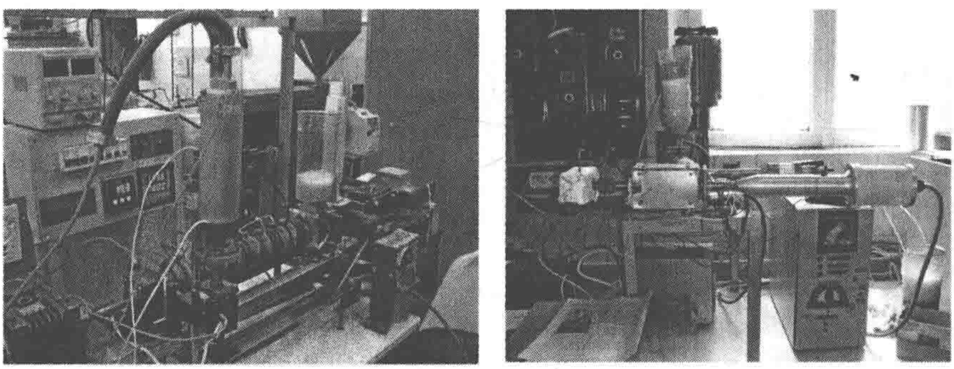
Hydrocerol BM 70 is a chemical substance that decomposes or reacts by the influence of heat. This is chemical, endothermic foaming agent. To achieve an optimum gas yield, a processing temperature of at least 180°C is suggested.

At the present time double-screw extruder and single-screw extruders with specific construction of screw are used for production of foamed materials. Double-screw extruders provide a better homogenization of the polymer melt then other types of equipment. They provide a more uniform distribution of blowing agent and nucleator in the volume of polymer during foaming processes. Based on the analysis of modern equipment for PP foaming, it was decided to create two special laboratory installations.

One of them is made on the basis of the double-screw extruder, with screws diameter 20 mm. It is used for obtaining of stands and cylindrical pellets. An installation includes pressure sensor, unit of ultrasonic processing, extrusion die (for one or two stands formation), bath for stands cooling, pulling device, and granulator. Azodicarbonamide is used as a blowing agent. Maximum productivity of installation is 8 kg/h.

Unit of ultrasonic processing is a bundle of ultrasonic vibration generator (oscillation frequency 22 kHz and capacity 1.5 kW), magnetostrictive vibration transducer, titanium sonotrode, and melt treatment chamber, which is attached to the outlet flange of the extruder. At the output of the camera is set strand die.

The second installation is made using the single-screw extruder, with barrier screw, screw diameter 12 mm. Hydrocerol BM-70 is used as a blowing agent. Maximum productivity of installation is 1.5 kg/h. An installation includes: pressure sensor, unit of ultrasonic processing and a set of capillaries for rheological studies directly during extrusion. The kit of ultrasonic unit includes an ultrasonic generator (oscillation frequency 22 kHz and capacity 300 W), piezoceramic vibration transducer, and titanium sonotrode. At the output of the camera is set slit die (width 100 mm). A system of rolls with air cooling is used for receiving of flat film. Thus, on the installation with a single-screw extruder, a strand can be obtained as well as the film material. Appearance of installations is shown in Figure (1.1a, b).



(a) (b)

FIGURE 1.1 Appearance of laboratory extrusion systems based on: (a) Double-screw extruder and (b) single-screw extruder.

The sonication of the polymer melt was carried out directly in the extruder under laboratory conditions by using apparatus for ultrasonic treatment. Without ultrasonic, ultrasound block was not dismantled, to provide constancy of process conditions.

Ultrasonic apparatus for processing the polymer melt represents a complicated system of blocks and elements consisting of transducer of electrical oscillations, system for concentrating of ultrasonic vibrations, instrument for input of ultrasonic vibrations, ultrasonic vibration generator, system of control, and automation.