

Index

a

- acoustic testing, kenaf fiber 179
- additive manufacturing (AM)
 - biomaterials 30
 - required properties 30–31
 - types 31–33
- generic process 33
- human bone 27
- mechanical characterization 38–41
- of porous biocomposites 35–36
- porous scaffold 29
 - bioceramics 37–38
 - pore geometry 37
 - pore size 36–37
- of porous structures 33
- powder bed fusion process 34–35
- aluminium hydroxide (Al(OH)_3)
 - 215–216
- aluminum silicon carbide (Al-SiC)
 - nanoparticles
- epoxy composite
 - dynamic mechanical analysis 195, 199–201
 - fabrication and volume fraction 195–196
 - flexural characteristics 197–198
 - flexural properties 194–195
 - impact characteristics 198–199
 - impact strength 195
 - morphological characteristics 201
 - morphological properties 195
 - porosity, density and volume fraction 194

tensile properties 194

tensile strength 196

epoxy composites 194

materials 193

production of 193

analysis of variance (ANOVA) 115, 116, 255

animal fibers 3, 135

artificial fibers 77

Arundo Donax filler 235

axial stiffness, ramie/flax 279

b

bacterial nanocellulose (BNC) 101

bagasse fiber (BF) 109

bagasse/jute FRP hybrid composites 11–12

bamboo/MFC FRP hybrid composites 12

bauhinia-vahlii-weight (BVW-R) 221

Bayer method 164

Bio-based composites 191

biochar 256

biochar filled *Sansevieria cylindrica* reinforced vinyl ester composites 236

biochar characterisation

FTIR absorbance spectrum 240–242

FT-IR spectroscopy 238–239

particle size analyser 238, 240

X-ray diffraction 238, 242–243

- biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester composites (*contd.*)
 Cole-Cole plot 246, 247
 dynamic mechanical analysis 239,
 243–247
 fabrication 239
 flexural tests 240, 248–249
 impact strength 240
 impact tests 249–250
 material specification 236
 scanning electron microscopy 240
 SEM micrograph 248
 storage modulus 243, 244
 tensile testing 239–240, 247–248
 biochar reinforced plastic composites
 256
 biocomposites 1
 factors influencing quality 82
 materials 49
 physical and mechanical properties
 fiber/particle size 85–88
 filler effect 88–91
 nanocellulose reinforced
 biocomposites 98
 natural fiber/polymer matrix
 compatibility 91–92, 94–96
 polymer matrix 95–96
 processing conditions, in
 manufacture 96–97
 voids and porosity 98
 biodegradability, fabric/PBS 280
 biodegradable material 32
 bleached red algae fibre (BRAF) 61
- c**
- calcium carbonate (CaCO_3) filler 217
 calotropis gigantea fiber (CGF) composite
 221–223
 cancellous bone 28
 carbon fibre reinforced composites 306
 carbon nanotubes 256
 cardanol polymer matrix composites
 208–209
 cashew nutshell biochar reinforced
 polyester composites
- biochar preparation 257
 fabrication 257
 flexural strength 259–260
 hardness 260–261
 impact strength 260
 mechanical testing 258
 slow pyrolysis process 257
 solution dispersion method 257
 tensile strength 258–259
 cashew nutshell waste 257
 cellulose 98
 cellulose micro filler (CMF) 208
 cellulose nanofibers
 industrial applications 101–103
 preparation and properties 101
 cellulose nanofibers (CNFs) 98
 cellulosic natural fibers 109
 ceramics 32
Clusia multiflora sawdust (CMS) 224
 coconut/cork FRP hybrid composites 14
 coir/silk FRP hybrid composites 15
 Cole-Cole plot, for bichar filled SCVEC
 246, 247
 compact tensile (CT) method 296
 composite delaminate detection method
 306
 compression moulding 177, 192
 compressive modulus (CM) 210
 compressive strength (CS) 210
 cork oak trees (*Quercus suber*) 14–15
 corn husk/kenaf FRP hybrid composites
 16
 cotton/jute and cotton/kapok FRP hybrid
 composites 16
- d**
- DCB method 296
 defence industry 102
 digital storage oscilloscope (DSO) 178
 double cantilever beam (DCB) method
 296
 drilling 110
 drug therapy 32
 dry leaves fiber 193, 196

- dynamic mechanical analysis (DMA)
 55, 124, 178, 305
- basalt/pineapple leaf fiber/epoxy
 matrix composites 306
- biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 239
- bio-nanocomposites 66–68
- epoxy composite 195–196, 199
 damping factor 201
 loss modulus 200–201
 storage modulus 199–200
- flax/basalt fiber reinforced polyester
 matrix composites 307
- hybrid fibre 64
 coir/PALF 65
 kenaf/PALF 65–66
- oil palm empty fruit bunch 66
- palmyra palm leaf stalk fiber 66
- sisal/oil palm 64–65
- mechanical properties of 175
- single fibre 57
 alfa 59
 bamboo 57–59
 banana 61–62
 carnauba 59–60
- flax 62
- hemp 63
- henequen 64
- jute 62
- kenaf 59
- oil palm fibre 60
- pineapple leaf fibre 60
- red algae 60–61
- sugar palm 57
- waste silk fibre 63–64
- untreated fiber reinforced composites
 306
- dynamic mechanical and thermal analysis
 (DMTA) 176
- dynamic mechanical properties (DMA)
 180
- e**
- edge crack torsion (ECT) test 298
- effectiveness coefficient (EC) 286
- effectual fiber reinforcement 163
- empty-fruit bunches (EFB) 18
- end-notched flexure (ENF) test 297
- epoxy composite
 dynamic mechanical analysis 195, 199
 fabrication and volume fraction
 195–196
- flexural characteristics 197–198
- flexural properties 194–195
- impact characteristics 198–199
- impact strength 195
- morphological properties 195
- porosity, density and volume fraction
 194
- tensile properties 194
- tensile strength 196
- ERD 197
- ERDA 197
- erosion mechanism 169
 fiber treatment effect 169–170
 impact angle effect 170–173
 material behaviour 171, 173
 red mud effect 170
- erosion parameters 163
- erosion rate equation 166
- f**
- fabrication method 51, 53
- Fickian diffusion, sisal/epoxy composites
 272
- filler reinforced polymer composites 255
- flax/basalt fiber reinforced polyester
 matrix composites
 damping factor (Tan D) response of
 308
- dynamic mechanical analysis 307
- fabrication of 307
- flax and basalt fiber properties 307
- loss modulus of 309–310
- polyester resin properties 307
- storage modulus of 309
- flax fiber 208
- flexural modulus
 biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 249

- flexural modulus (*contd.*)
 ramie fiber/PBS composites 280
- flexural properties, sisal/epoxy
 composites 269–271
- flexural strength
 biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 248, 249
- cashew nutshell biochar reinforced
 polyester composites 259
- ramie fiber/PBS composites 280
- flexural test 296
 biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 240
- fracture energy, of biocomposites
 fibre parameters 298–299
 hybridization 299
 water aging 301–302
- fracture modes 294
- fracture morphology, ramie fiber epoxy
 281
- fracture surface morphology,
 ramie/flax/epoxy 279
- fracture toughness
 ASTM standards 295
 end-notched flexure test (ENF) 297
 mode III loading
 Edge Crack torsion test 298
 mixed mode bend test 298
 SCB method 297–298
 mode I loading
 compact tensile method 296
 DCB method 296
 single edge notch bend test 296–297
 mode II loading 297
 of RHA/Al₂O₃/Al-Mg-Si hybrid
 composite 299, 300
 test methods
 based on mode of delamination 294
 classification of 295
- fused deposition modeling (FDM) 35
- g**
- glass fibers 79
- glass transition 127
- h**
- hardwood fibers 81
- hazelnut shell (HS) 223
- heat deflection temperature (HDT) 21
- hemp fiber reinforced composites 306
- high density polyethylene (HDPE) 181, 182
- high processing temperature (HPT) 182
- human bone
 calcium homeostasis 27
 constituents 28
 forms 28
 mechanical properties 29
 structure 29
- hybrid composite
 chemical treatment 164
 erosion test 164
- hybrid composites containing
 high-density polyethylene
 (HDPE) 14
- hybrid fibre 64
 coir/PALF 65
 kenaf/PALF 65–66
 oil palm empty fruit bunch 66
 palmyra palm leaf stalk fiber 66
 PF/CMF 208
 sisal/oil palm 64, 65
- hybrid natural FRP composites
 bagasse/jute 11–12
 bamboo/MFC 12
 banana/kenaf and banana/sisal 12–14
 coconut/cork 14–15
 coir/silk 15–16
 corn husk/kenaf 16
 cotton/jute and cotton/kapok 16–17
 jute/OPEFB 18
 Kenaf/PALF 18–19
 sisal/rose and sisal/silk 19–20
 hydroxyapatite (HA) 37
- i**
- impact strength
 biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 240, 249

cashew nutshell biochar reinforced
polyester composites 260
ramie fiber/PBS composites
280
injection moulding 97
interlaminar shear strength (ILSS)
ramie fiber/PBS composites 280
ramie fiber reinforced polypropylene
composites 280

j

jute fiber 164
chemical treatment 166–167
epoxy composite 212–214
polyester composites 211–212
jute/OPEFB FRP hybrid composites
18

k

kenaf fiber (KF) 121
damping factor 126–127
domestication 121
dynamic mechanical analysis
124–125
glass transition 127–130
mechanical properties 122–124
reinforced composites
characterization
acoustic properties 179
dynamic mechanical analysis
178
thermogravimetric analysis 178
vibration-damping testing
178–179
dynamics properties
acoustic properties 186–187
dynamic mechanical properties
180–184
TGA analysis of composites
184–186
manufacturing techniques
176–177
storage modulus 125–126
Kenaf/PALF FRP hybrid composites 18
Kevlar based composites 306

l

loss modulus
biochar filled *Sansevieria cylindrica*
reinforced vinyl ester
composites 244
of flax/basalt fiber reinforced polyester
matrix composites 309–310
of glass/ramie composites 286

m

machining parameters 116
macropores 28
macro-scale fibre 50
maize residues 235
man-made fibers 77
metals 31
microfibrillated cellulose (MFC) 12, 101
mineral fibers 135
mixed mode bend (MMB) test 298
moisture diffusion, sisal/epoxy
composites 267
multivariable non-linear regression Model
113

n

nanocellulose
dispersion and distribution 53
loading 53
orientation 53
nanocellulose fiber (NCF) 53
nanocellulose reinforced bio-composites
98
advantages 98–99
cellulose nanofibers 101
disadvantages 99
nano clay (NC) 211
nano-crystalline cellulose (NCC) 101
nano-scale fibre
bio-nanocomposites 54
fabrication method 51–53
factors affecting 50–51
nanocellulose
dispersion and distribution 53
loading 53
orientation 53

- NaOH treated jute mat (NJM) 211
 natural fiber polymer composite
 areca fine fiber fillers 221–223
 Bauhinia vahlii–Sisal fiber epoxy
 composite 221
 cardanol polymer matrix composites
 208–209
 cellulose micro filler 208
 CGF phenol formaldehyde composite
 221–223
 dipotassium phosphate filler 220
 flax fiber liquid thermoplastic
 composite 223
 ground nut shell 220
 jute fiber epoxy composite 212–214,
 225–226
 jute fiber polyester composites
 211–212
 kevlar fiber epoxy composite 216–217
 Luffa cylindrica fiber polyester
 composite 220
 luffa fiber epoxy composite 217–218
 natural rubber composites 209–210
 palm and coconut shell filler 216
 phaseolus vulgaris fiber polyester
 composite 214–215
 physical and mechanical properties
 227
 pineapple leaf, Napier and hemp fiber
 filler 218–220
 polyester composite 217
 red banana peduncle fiber polyester
 composite 225
 SiO₂ filler 214
 vulgaris banana fiber epoxy composite
 215–216
 walnut shell, hazelnut shell 223–224
 waste vegetable peel fillers 224
 wheat straw fiber natural rubber
 composite 220
 wood fiber geo polymer composites
 210–211
 natural fibers 3, 77, 109, 135, 265
 advantages 305
 applications 293
 benefits of 265
 chemical composition 79
 classification 78, 136
 drawbacks 136–137, 305
 mechanical properties 135–136
 physical and mechanical properties
 80
 sale prices 79
 selection 82, 84
 surface modification
 acetylation treatment 143–144
 alkaline treatment 137–140
 benzylation treatment 145–146
 chemical treatment 137
 corona treatment 154–155
 isocyanate 148–150
 maleated coupling agents 147–148
 ozone treatment 155–156
 permanganate treatment 150–151
 peroxide treatment 146–147
 physical treatment 152
 plasma treatment 152–154
 saline treatment 140–143
 stearic acid treatment 151–152
 types of 293
 natural fibre reinforced polymer (FRP)
 composites
 benefits 7
 chemical compositions 4
 concept of 3–7
 drawbacks 7
 features 1
 hybridisation 7–10
 industrial applications 1
 manufacturing processes 6
 matrix material 1
 mechanical behaviours 2, 10–20
 polymer matrices 4–7
 natural rubber composites 209
 Non-Fickian diffusion 272
- O**
- oil palm (*Elaeis guineensis*) 18
 oil palm empty fruit bunch (OPEFB) 66
 oil palm fibre (OPF) 60

p

palmyra palm leaf stalk fiber (PPLSF) 66
 phaseolus vulgaris fiber polyester composite 214
 phenol formaldehyde (PF) composite 221
 pineapple leaf fibres (PALF) 18, 60, 218
 plant fibers 3, 79, 135
 advantages 79, 81
 disadvantages 81
 polyester composite 217
 polyester matrix 164
 polylactic acid (PLLA) composites 180
 polymer matrices 4
 polymer matrix composite (PMC) 109, 110, 175
 polymers 31
 polypropylene (PP) composites 184
Portunus sanguinolentus 212
 powder bed fusion (PBF) process 34
 powder of eggshell (ESP) 211
 pyrolysis process, biochar preparation 256

q

quasi-static mechanical performances 49

r

ramie/eco-flex nano-fiber composites 276
 ramie fabric composites 276
 ramie fabric fiber reinforced poly butylene succinate composites 280
 amino functionalized 280
 rheological characterization 280
 thermal-compression method 280
 thermo-compression method 280
 ramie fiber composites
 dynamic properties of 281–288
 mechanical strength 277–281
 ramie fiber reinforced polypropylene composites 276, 278
 3-Aminopropyltriethoxysilane treated 279

characteristics of 277
 graphene oxide treatment 280
 ramie fibers
 forms of 277
 hybridization of 277, 278
 physical properties 275
 surface modification of 281
 ramie/flax/epoxy hybrid composites 279
 ramie/flax reinforced bio-epoxy composites
 damping factor 284–288
 dynamic mechanical analysis 281, 282
 SEM fractography 287–288
 storage modulus 283–284
 temperature influence 283
 viscous modulus 284
 raw jute mat (UJM) 211
 red banana peduncle fiber (RBPF) 225
 red banana peduncle wood fiber (RBWF) 225
 red mud 164
 regression model 117
 resin transfer molding (RTM) 177

s

scanning electron microscopy (SEM) 166, 195
 Segal analytical method 166
 short fiber reinforced thermoplastics 176
 single edge notch bend (SENB) test 297
 single fibre 57
 alfa 59
 bamboo 57–59
 banana 61–62
 carnauba 59–60
 flax 62
 hemp 63
 henequen 64
 jute 62
 kenaf 59
 oil palm fibre 60
 pineapple leaf fibre 60
 red algae 60–61

- single fibre (*contd.*)
 sugar palm 57
 waste silk fibre 63–64
- sisal (*Agave sisalana*) 19
- sisal/epoxy composites
 fabrication method 266
 Fickian diffusion behavior 272
 flexural properties 269–271
 flexural tests 267
 moisture diffusion 267, 271
 non-Fickian diffusion behavior 272
 technical fibre and resin specifications
 266–267
- tensile failure 269
- tensile load-elongation plot 267–268
- tensile properties 267–269
- tensile tests 266–267
 water absorption study 271–272
- sisal fibres
 loading 266
 strength and stiffness 265
- sisal/hemp/bioepoxy composites 306
- sisal/rose and sisal/silk FRP hybrid
 composites 19
- S/N ratio 115
- sodium hydroxide (NaOH) alkali solution
 12
- softwood fibers 81
- split cantilever beam (SCB) method 297
- storage modulus
 biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 243–244
- of glass/ramie composites 285
 of ramie/flax reinforced bio-epoxy
 composites 283–284
- sugar-bearing juice 111
- sugarcane bagasse (SCBT) 11, 209
 cardanol polymer matrix composites
 208–209
 natural rubber composites 209–10
- sunflower husk (SH) fillers 223
- synthetic fibers 109, 121
- synthetic filler 207
- synthetic styrene butadiene rubber (SBR)
 224
- t**
- Taguchi methodology 110
- tan delta
 of flax/basalt fiber reinforced polyester
 matrix composites 308
 ramie/flax reinforced bio-epoxy
 composites 284–288
- tensile modulus, SCVEC 247–248
- tensile properties, sisal/epoxy composites
 267–269
- tensile strength
 aluminum silicon carbide 196–197
 for biochar filled SCVEC 247–248
 cashew nutshell biochar reinforced
 polyester composites 258–259
 corn starch biochar filled composites
 256
- glass fiber reinforced composites 277
- natural rubber 210
- ramie fiber/PBS composites 280
- ramie fiber reinforced composites
 277–281
- silane treated ramie fiber PP matrix
 279
- various composites 213
- tensile testing
 biochar filled *Sansevieria cylindrica*
 reinforced vinyl ester
 composites 239–240
 biochar filled SCVEC 247–248
- thermal behaviour 21
- thermal property 21
- thermogravimetric analysis (TGA) 21,
 178
- thermoplastic resins 4
- thermosetting resins 4
- three-point flexural test 194
- thrust force 115
- tissue engineering 27
- torque 114
- tribological behaviour 20

V

- vibration-damping testing 178
viscous modulus 284

W

- walnut shell (WS) 223
waste silk fibre (WSF) 64
water absorption study, sisal/epoxy
 271–272
water aging
 cotton/geopolymer composites
 301
 flax/basalt hybrid vinyl ester
 composites 301
 hemp/PLA composites 301
Kenaf/glass-based polyester composites
 301

- wheat straw fiber natural rubber
 composite 220
woven fiber 169

Y

- Young's modulus 279

Z

- Zea maize cob
 particle size 236
 temperature for biochar preparation
 235
Zea mays cob 235
 FTIR absorbance spectrum 240–242
 particle distribution curve 240
 SEM-EDAX 236–238
 X-ray diffraction analysis 242–243

