## SUBJECT INDEX

Note: The letters 'f' and 't' following locators refer to figures and tables respectively.

```
Acid-catalyzed microreactions
                                                      heat application to enzymes, effects,
  aldehyde protection as its dimethyl acetal,
                                                        88-89
                                                   MOF, separation of gas mixtures, 87-88
  continuous flow thioacetalizations, 141t
                                                   physical/chemical field effects, 85-86
                                                   protein adsorption (reversible and
  continuous flow thioketalizations using
     EOF, 142t
                                                      nonspecific), 89-90
  enantioselective synthesis in microreactor,
                                                   protein microarrays, development of, 90-91
                                                 Alkylation of N-acyl oxazolidinone, 117, 117f
  Strecker reaction, PS-RuCl<sub>3</sub>/PS-Sc(OTf)<sub>2</sub>,
                                                 Aminonaphthalene derivative, synthesis of,
                                                      181, 182f
  synthesis of dimethyl acetals under
                                                 α-Aminophosphonates synthesis,
     continuous flow, 140t
                                                      Kabachnick-Fields reaction, 111, 111f
N-Acyl oxazolidinone, alkylation of, 117,
                                                 Amphibole, 225, 226f
                                                 Applications of microplasma reactors
Adsorbed molecules, control of activity
                                                   chemical synthesis
  adsorbing proteins, orientation
                                                      ammonia/CO2 decomposition, use of
     experimental study, SIMS/atomic force
                                                        MHCD, 57-58
        microscopy, 92
                                                      fabricated plastic microreactors, study
     theoretical study, molecular/
                                                        (Anderson), 61
        continuum models, 91-92
                                                      hydroxylation of benzene and toluene
  external electric field effects, 92-93
                                                        by DBD, 58-59, 58f
  NEMCA effect, mechanism, 94-95
                                                      oxidative conversion of C<sub>1</sub>-C<sub>3</sub> alkanes
  PABA, potential-dependent orientation
                                                        by DBD, 59-60, 59f
     effect, 91
                                                      partial oxidation of methane,
                                                        microreactor setup, 56-57, 57f
Adsorption-desorption by electrical fields
  adsorption control on surface, principles
                                                   environmental applications
     FET configuration by gate potential, 89
                                                      CO<sub>2</sub> decomposition by plasma reactors,
     field-effect control, 89
                                                        54-55, 55f
                                                      nanostructures as electrodes, 55, 56f
  interaction of gases with catalyst surfaces
     FEM. 86
                                                      tetrafluoromethane decomposition by
     FIM, 86
                                                        microreactors, 54, 54f
     interaction of CO and O2 with gold,
                                                      VOCs decomposition by microplasma
        86-87, 87f
                                                        reactors, 53-54, 53f
  'microorganism' as a microreactor
                                                   nanostructure synthesis
     enzymes immobilization strategies, 88
                                                      CNF growth, 51
```

Applications of microplasma reactors	effectiveness of automation process,
(Continued)	criteria, 211
microplasma in capillary/Pyrex chip,	ideal behavior, 211f
52, 53f	key features, 211–212
microreactor/catalyst coating/	MAUFs/SAUFs, 220
microplasma treatment, 51, 52f	minimization routines
synthesis of Fe/Ni catalyst particles	design, conditions, 213-214
(Chiang & Sankaran), 49	optimization techniques. See Noise-free
synthesis of MoO2 nanoparticles with	optimization, technique
UHF, 50–51, 50f	nanoparticles formation with desired
synthesis of photoluminescent silicon	properties, set up, 212f
nanocrystals by VHF, 49, 50f	parts of
synthesis of silicon nanoparticles	decision-making software, 211
(Sankaran), 48, 49f	online detectors, 211
UHF technique in MWCNTs, 51	physical machinery, 211
plasma generation in liquid/at liquid	search process for optimization routines,
interface, 61-67. See also	phases
Electrohydraulic discharge	global searching, 222
Arylation of octafluorocyclopentene, 178t	local searching, 222
Asbestos fibers, types	utility function, 212, 213f
amphibole, 225, 226f	
serpentine, 225, 226f	Band-edge emission, 209, 209f
Atmospheric pressure microplasmas	Barton reaction (nitrite photolysis),
classification factors, 41, 42	188, 190t
DBDs and configurations, 43-44, 44f	Base-promoted microreactions, 136-139
DC glow discharges, 42, 43f	AO-DMAP as catalyst for acylation of 2°
field emission from tip electrodes,	alcohols, 138, 138f
45–48	
	base-catalyzed Knoevenagel
MHCDs, 44–45, 44f	condensation, 136, 136f
microcavity discharges, 45, 45f	condensation, 136, 136f derivatization of PGMA polymer, model
microcavity discharges, 45, 45f examples	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f
microcavity discharges, 45, 45f examples arc discharges, 39	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of ( <i>E</i> )-ethyl-2-cyano-3-
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137,
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. <i>See also</i>	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of ( <i>E</i> )-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles,
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of ( <i>E</i> )-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of ( <i>E</i> )-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41 plasma temperature, 41	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid tert-butyl ester, microreactions used,
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41 plasma temperature, 41 Automated microreactors	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid tert-butyl ester, microreactions used, 182, 183f
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41 plasma temperature, 41 Automated microreactors application in nanotoxicology	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid tert-butyl ester, microreactions used, 182, 183f Biocatalysis reactions
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41 plasma temperature, 41 Automated microreactors application in nanotoxicology asbestos fibers, types, 225, 226f	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid tert-butyl ester, microreactions used, 182, 183f Biocatalysis reactions biocatalytic hydrolysis of
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41 plasma temperature, 41 Automated microreactors application in nanotoxicology asbestos fibers, types, 225, 226f libraries of RMs, study, 227	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid tert-butyl ester, microreactions used, 182, 183f Biocatalysis reactions biocatalytic hydrolysis of 2-phenoxymethyloxirane, 152f
microcavity discharges, 45, 45f examples arc discharges, 39 corona discharge, 39 DBD, 39 high-pressure plasmas, 42. See also Microplasma nonequilibrium atmospheric pressure plasma applications, 41–42 plasma state, 41 plasma temperature, 41 Automated microreactors application in nanotoxicology asbestos fibers, types, 225, 226f	condensation, 136, 136f derivatization of PGMA polymer, model reaction, 138, 138f synthesis of (E)-ethyl-2-cyano-3- phenylacrylate, model reaction, 137, 137f synthesis of thiazoles and imidazoles, 138–139, 139f, 139t α,β-unsaturated compounds synthesis by silica-supported base, 137t Bead-packed microchannels, 11–12, 12f (4-Benzyloxynaphthalen-2-yl)-carbamic acid tert-butyl ester, microreactions used, 182, 183f Biocatalysis reactions biocatalytic hydrolysis of

continuous flow optical synthesis of thiazoles and imidazoles, resolution of acetyl-D,L-phenylalanine, 138-139, 139f, 139t  $\alpha,\beta$ -unsaturated compounds synthesis by silica-supported base, 137t enzymatic synthesis of L-lactate, 157f immobilization of His6-tagged proteins, 156f biocatalysis PDMS microreactor, reactions conducted continuous flow ester hydrolysis using in, 154f-155f His6-tag BsubpNBE, 157f Biphasic fluorination, 122 continuous flow optical resolution of "Black-box" automated reactors, 211 acetyl-D,L-phenylalanine, 156f Black-box technique. See Simplex method enzymatic synthesis of L-lactate, 157f Block copolymers, 132 hydrolysis of 2-phenoxymethyloxirane, BOLSIG+ software, 60 Bond (Bo) number, 15 immobilization of His6-tagged proteins, Bromination reactions, 115, 115f 156f PDMS microreactor, reactions conducted in, 154f-155f CAD. See Computer-aided design (CAD) Capillarity restricted modification (CARM) metal-catalyzed reactions, 145-148 continuous flow Heck-Mizoriki method, 27, 29f Carbamates, exothermic synthesis, 176f reaction, 146t continuous flow Suzuki-Miyaura Carbon nanofiber (CNF), 51 Carbon nanotubes (CNTs), 47. See also reaction, 145t Multiwalled carbon nanotubes kinetic resolution of rac-4-hdroxy-1-(MWCNTs) butene oxide, 146, 146f CARM method. See Capillarity restricted Suzuki-Miyaura coupling reactions, modification (CARM) method 147t Catalyst incorporation into microreactors multiple catalyst systems acid-catalyzed microreactions multistep synthesis of an aldehyde protection as its dimethyl  $\alpha,\beta$ -unsaturated compound, acetal, 140f 149f continuous flow thioacetalizations, 141t polymer-assisted derivatization of continuous flow thioketalizations using steroid, 149f EOF, 142t solid-supported reagents in single enantioselective synthesis in pressure-driven flow reactor, microreactor, 143f Strecker reaction, PS-RuCl<sub>3</sub>/PS-Sc synthesis of 2-(benzyloxy) (OTf)2, 144t tetrahydropyran, 151t synthesis of dimethyl acetals, "Cation flow" process, 68 continuous flow, 140t CdSe nanoparticles, production of base-promoted microreactions, 136-139 Peng's method, 208 AO-DMAP as catalyst for acylation of reactor design, 208f 2° alcohols, 138, 138f TEM image/emission spectrum/ base-catalyzed Knoevenagel wavelenghts, 208-209, 209f condensation, 136, 136f temperature dependence of emission derivatization of a PGMA polymer, spectra of, 209, 210f model reaction, 138, 138f total flow-rate dependence of emission synthesis of (E)-ethyl-2-cyano-3spectra of, 209, 210f phenylacrylate, model reaction, 137, CFCP. See Continuous-flow chemical 137f processing (CFCP)

Chemical reactions, electrokinetic control of	electrons injected into liquid by
electrophoresis/electroosmosis, 72-77	nanowires, 66-67
EWOD, 81–82	flue gas desulfurization, 64
positioning/trapping of particles/	liquid paraffin in glow-discharge
molecules, 77-81	plasma, 64–65
special effects	segmented flow patterns with DBD, 66,
electric swing adsorption, 83–84	66f
electric wind, 82–83	
electrospray, 84–85	DBD. See Dielectric barrier discharge (DBD)
pulsed electric fields, 84	DC glow discharges, 42, 43f
Chemical surface modification methods	Decomposition of enolate, batch conditions,
Beebe's group study	117–118, 118f
by multiphase laminar microflows, 26,	Dehydration of β-hydroxyketones, 112, 112f
26f	MRT/batch flow approach, 112
UV photopatterning method, 26–27, 28f	DEP. See Dielectrophoresis (DEP)
Kitamori's group study	Deprotonation of styrene oxide, reaction
CARM method, 27, 29f	products, 131t
Chemical synthesis in microplasma reactors	Derjaguin–Landau–Verwey–Overbeek
ammonia/CO <sub>2</sub> decomposition, use of	theory, 92
MHCD, 57–58	Dielectric barrier discharge (DBD), 39, 43–44,
fabricated plastic microreactors, study	44f
(Anderson), 61	Dielectrophoresis (DEP), 39
hydroxylation of benzene and toluene by	2,4-Dihydrobenzoic acid from resorcinol,
DBD, 58–59, 58f	Kolbe-Schmitt synthesis, 112, 112f
oxidative conversion of $C_1$ – $C_3$ alkanes by	in microreactor/batch reactor, 113
DBD, 59–60, 59f	Domino reactions (Fernandez-Suarez), 105,
partial oxidation of methane, microreactor	105f
setup, 56–57, 57f	Duocarmycin synthesis, 181f
Chemkin plasma reactor model, 60	Duocumiyem synthesis, 1011
CNF. See Carbon nanofiber (CNF)	Efaproxiral synthesis, batch/flow
CNTs. See Carbon nanotubes (CNTs)	methodology, 180f
Computer sided design (CAD) 11	Electric swing adsorption, 83–84 Electrochemical microreactors
Computer-aided design (CAD), 11	
Continuous-flow chemical processing	carbocations for nucleophilic reactions, 70
(CFCP), 1–33	cofactor generation  DNA restriction schemes, 72
Conventional emission spectroscopy	
techniques, 65	immobilization of enzymes, 71
Corona discharge	microfluidic fuel cell, 68
application, 39	microreactor coupling to separation
configurations, 63, 63f	methods, 70-71
gas-liquid pulsed corona discharge	electrochemistry at static triple-phase
reactor, applications	boundaries, 69
aqueous electrode chip design, 65f	electrosynthesis in microfluidic system,
conventional emission spectroscopy	purpose, 67–68
techniques, 65	'supporting electrolyte' elimination
degradation of 4-chlorophenol in water,	two-phase flow with NOP, 69
64	Electrochemistry, 38
electrolyte as a cathode discharge, 65	Electrohydraulic discharge

corona discharge. See Corona discharge model reaction, 129, 129f pulsed arc discharge, 63 optimization strategy, 130t Electromigration dispersion, 74 FET. See Field-effect transistor (FET) Electronic control of reactions at surfaces Field-effect flow control principle, 89 adsorption-desorption by electrical fields, Field-effect transistor (FET), 89 Field emission, definition, 46 control of activity of adsorbed molecules, Field emission from tip electrodes 91 - 95current determination, Fowler-Nordheim Electroosmosis, 39, 72–77 equation, 46 Electrophoresis, 39, 72 gate electrode, features, 47-48 Electrophoretically mediated microanalysis, 75 nanowires, applications, 47 Electrospray, 84–85 Paschen curve, 45, 46f Spindt type emitter, 47 Electrowetting-on-dielectric (EWOD), 39, 81 - 82with integrated gate electrode, 47f Enhanced reaction control by MRT Field emission microscopy (FEM), 86 acylation of primary amines Field-induced adsorption/desorption. See deuterium labels incorporation, Adsorption-desorption by electrical method, 110, 110f fields Domino reactions in a soda-lime Field ion microscopy (FIM), 86 microreactor, 105, 105f FIM. See Field ion microscopy (FIM) Fluorination of β-diketoester, 122, 122f ester synthesis in EOF-based microreactor, 109, 109f Fluorinations in organic molecules (Miyake synthesis of 1,2-azoles by EOF, 105–106, and Kitazume) 122-127 Horner-Wadsworth-Emmons reaction, synthesis of chromenones, 106-107, 107f, 123, 126f Michael addition reaction, 123, 126f 3-amino-4-(arylamino)-1H-isochromen-Formation of nanoparticles 1-ones, model reaction, 108f continuous-flow synthesis of ZnS-coated 1H-isochromeno[3,4-d]imidazol-5-ones CdSe composite particles, 203, 204f synthesis, 109t in microfluidic device Environmental applications of microplasma absence of turbulence, advantage, 202 benefits, 198-199 CO<sub>2</sub> decomposition by plasma reactors, in chemical synthesis, features, 199 choice of solvent, criteria, 202-203 54-55, 55f nanostructures as electrodes, 55, 56f fabrication materials, 200 tetrafluoromethane decomposition by lab-on-a-chip, 199 microreactors, 54, 54f used for DNA processing, 200f VOCs decomposition by microplasma using wet lithography, 199f reactors, 53-54, 53f y-shaped microfluidic device, design, EWOD. See Electrowetting-on-dielectric 201, 201f nucleation stage/growth phase, 197, 198f (EWOD) Exothermic synthesis of carbamates, 176f one-pot synthesis of II-VI nanoparticles, Extended nanospace, 4 findings, 206 sulfur colloids, formation of, 197 Fanetizole, continuous flow synthesis, 175f "supersaturation"/"critical" FEM. See Field emission microscopy (FEM) concentration, 197 Fenchone/2-bromopyridine, one-step synthesis of anisotropic particles coupling (Millman), 206

Formation of nanoparticles (Continued) synthesis of CdSe nanoparticles, 203 synthesis of CdSe/ZnS and CdS/ZnS nanoparticles, 205, 205f synthesis of high-quality CdSe quantum dots, 206, 207f synthesis of ZnS/CdSe/ZnS QDQW, 203–204

Ostwald ripening of cores, effects, 204 "top-down"/"bottom-up" approach, 196

Fowler–Nordheim equation, 46

Gas chromatography-mass spectrometry (GC-MS), 13, 109 Gate electrode, features, 47–48 GC-MS. See Gas chromatography-mass

Grossamide synthesis, 187f

spectrometry (GC-MS)

Halide displacement reaction, 115, 115f Heterogeneous immunoassay integration of ELISA with microchip bead-packed microchannels, use of, 11–12, 12f

His<sub>6</sub>-tagged proteins benzoin/cross-benzoin reaction, 156f immobilization of, 156f

HIV-1 RTI analog, continuous flow synthesis, 186f

Horner–Wadsworth–Emmons reaction, 123, 126, 126f

comparison of stereoselectivities in batch/ microreactor, 126, 127t

Hydraulic diameter, 16

Hydrolysis free O-acylation of alcohols, 114, 114f

6-Hydroxybuspirone, synthesis of, 184f

Industrial applications of MRT
arylation of octafluorocyclopentene, 178t
(4-benzyloxynaphthalen-2-yl)-carbamic
acid tert-butyl ester, microreactions
used, 182, 183f
continuous flow synthesis of a HIV-1 RTI
analog, 186f

continuous flow synthesis of fanetizole,

184-185, 185f continuous flow synthesis of rimonabant, continuous flow synthesis of spiro lactone derivative, 174f, 175t conversion of nitrite to oxime, 189, 189f exothermic synthesis of carbamates, 176f flow-assisted synthesis of (+)oxomaritidine, 188f photochromism by diarylethenes, 176f Photooxygenation of (–)-β-citronellol, 191f synthesis of aminonaphthalene derivative, 181, 182f synthesis of duocarmycin, 181f synthesis of efaproxiral, batch/flow methodology, 180f synthesis of grossamide, 187f synthesis of 6-hydroxybuspirone, 184f synthesis of radiolabel 2-[18F]fluorodeoxyglucose (2-[18F]-FDG), 185f synthesis of symmetrical/unsymmetrical diarylethenes, 177f

continuous flow synthesis of pristane,

Kolbe-Schmitt reaction, 112

Lab-on-a-chip, 199 Langmuir–Hinshelwood mechanism, 86 Laplace pressure ( $\Delta P_{Laplace}$ ), 20, 20f, 24, 32, 33

Laser-Raman scattering spectroscopy, 65

MAUFs. See Multi-attribute utility functions (MAUFs)

Metal-catalyzed reactions, 145–148 continuous flow Heck–Mizoriki reaction, 146t

continuous flow Suzuki-Miyaura reaction, 145t

kinetic resolution of rac-4-hdroxy-1butene oxide, 146, 146f

Suzuki-Miyaura coupling reactions, 147t Metal-organic framework (MOF), 87 MHCDs. *See* Micro hollow cathode discharges (MHCDs)

Michael addition reaction, 123, 126, 126f Microcavity discharges, 42, 45, 45f

239

Microchemical (integrated) systems, design/	nanoparticle formation. See Formation of
construction	nanoparticles
microchemical processes, example of,	process control, 222-224
6–14, 9t–10t	production of CdSe nanoparticles. See
multiphase microflow network, 5-6, 5f	CdSe nanoparticles, production of
Microchemical processes, example of, 9t–10t	synthesis of nanoparticles, microfluidic
Co wet analysis. See Micro cobalt wet	routes, 197-208. See also Formation of
analysis	nanoparticles
microimmunoassay	Micro hollow cathode discharges (MHCDs),
clinical diagnosis, application/	44–45, 44f
limitation, 11, 12	Microplasma, 42
design of, 12f	Microplasma reactors
heterogeneous immunoassay, 11	applications, 48–67
micro-ELISA system, 12, 13f	atmospheric pressure microplasmas,
molecular transport in microspace, 6-7	41–48
urine analysis	chemical synthesis in
conventional procedures, 13, 14f	ammonia/CO2 decomposition, use of
GC-MS technique, 13	MHCD, 57–58
microsystems for, 14f	fabricated plastic microreactors, study
system design, MUOs/CFCP approach,	(Anderson), 61
14f	hydroxylation of benzene and toluene
Microchip electrophoresis, 5	by DBD, 58-59, 58f
Micro cobalt wet analysis	oxidative conversion of C <sub>1</sub> -C <sub>3</sub> alkanes
CAD, application, 11	by DBD, 59-60, 59f
conventional procedures, 7	partial oxidation of methane,
diffusion time dependence on diffusion	microreactor setup, 56-57, 57f
length, 7f	Microreaction technology (MRT), 40, 104
extraction/purification reactions, 8	Microreactors with electrical fields
system design, CFCP approach, 8f	chemistry and electricity
Microcountercurrent flow patterns, 27-31,	electrochemistry, 38
29f, 30f	MRT, 40
MicroELISA system, 3, 12, 13f	plasma chemistry, 38. See also Plasma
Microfluidic droplet reactors, 206	chemistry/technology
Microfluidic fuel cell, 68	electrochemical microreactors, 67-72
colaminar configuration, advantages,	electrokinetic control of chemical reactions
68–69	electrophoresis and electroosmosis,
example, 69f	72–77
laminar flow characteristic, 68	electrowetting-on-dielectric, 81-82
Microfluidic reactors for nanomaterial	positioning/trapping of particles/
synthesis	molecules, 77-81
automated microreactors application in	special effects, 82–85
nanotoxicology	electronic control of reactions at surfaces
asbestos fibers, types, 225, 226f	adsorption-desorption. See
libraries of RMs, study, 227	Adsorption-desorption by electrical
"scale-out" process, benefits, 228	fields
toxicity, influencing factors, 227	control of activity of adsorbed
automated production of nanoparticles.	molecules. See Adsorbed molecules,
See Automated microreactors	control of activity

Microreactors with electrical fields	thermal control, 111–120
(Continued)	toxic/hazardous reagents, use of. See also
microplasma reactors	Toxic/hazardous reagents in MRT
applications. See Applications of	continuous flow hydrosilylations using
microplasma reactors	tris(trimethylsilyl)silane, 121t
atmospheric pressure microplasmas.	exothermic reactions, 135
See Atmospheric pressure	fluorinations, 122-127
microplasmas	nitrations, 132–135
Microscopic quasielastic laser scattering	trimethylaluminum, 127
method, 31	tris(trimethylsilyl)silane-mediated
Microsegmented flows, 6	deoxygenation/dehalogenation
Micro-SMB separators, 71	reactions, 120–121
Microunit operations (MUOs), 1–33	use of butyllithium in microreactors,
Microwave-assisted reactions	127–132
bromination reactions, 115, 115f	Multi-attribute utility functions (MAUFs),
halide displacement reaction, 115, 115f	220
Suzuki-Miyaura reaction, 114, 114f	Multiphase microflow(s)
model for optimization of microwave-	methods of stabilization, 25-32
assisted reactions, 116t	physical properties. See Physical
Wittig-Horner olefination, 115	properties of multiphase microflows
Microwave irradiation, 111, 114	wettability-based microvalve, 32-33
MOF. See Metal-organic framework (MOF)	Multiphase microflow network, 5-6, 5f
Molecular Dynamics or Monte Carlo	electroosmotic flow, 5-6
simulations, 91	microsegmented flows, 6
MRT. See Microreaction technology (MRT)	pressure-driven flow, 6
MRT, high-throughput organic synthesis by	Multiple catalyst systems
advantages over batch vessels, 104-105	multistep synthesis of an $\alpha,\beta$ -
catalyst incorporation into microreactors	unsaturated compound, 149f
acid-catalyzed microreactions, 140-144	polymer-assisted derivatization of steroid
base-promoted microreactions, 136-139	149f
biocatalysis, 152-158	single pressure-driven flow reactor, use of
metal-catalyzed reactions, 145-148	solid-supported reagents, 150f
multiple catalyst systems, 148-152	synthesis of 2-(benzyloxy)
enhanced reaction control	tetrahydropyran, 151t
Domino reactions in a soda-lime	Multiwalled carbon nanotubes (MWCNTs),
microreactor, 105, 105f	51
synthesis of 1,2-azoles by EOF, 105-106,	MUOs. See Microunit operations (MUOs)
106t	MUOs and CFCP
synthesis of chromenones, 106-107,	integrated microchemical systems,
107f, 108t	design/construction
industrial applications. See Industrial	microchemical processes, example of,
applications of MRT	6–14
photochemical reactions, 164-174	multiphase microflow network, 5-6
solid-supported reagents in noncatalytic	microchemical chip/electronic system,
flow processes	comparison, 3f
heterogeneous photochemistry, 170-	microtechnology, directions, 3-4
173	multiphase microflows
homogeneous photochemistry, 166-169	fundamental physical properties, 14-25

methods of stabilization, 25-32	Photolithography, 26–27
wettability-based microvalve, 32-33	Photooxygenation of (–)-β-citronellol, 191f
MWCNTs. See Multiwalled carbon	Physical properties of multiphase
nanotubes (MWCNTs)	microflows, 14-25
	air-liquid microflows
Nanostructure synthesis in microplasma	phase separation conditions, 24, 25f
reactors	interfacial tension between air-solvent/
CNF growth, 51	aqueous-organic interfaces at 20°C, 23t
microplasma in a capillary and in Pyrex	liquid-liquid microflows, 15f
chip, 52, 53f	phase separation conditions, 23, 24f
microreactor/catalyst coating/	of multiphase microflows
microplasma treatment, 51, 52f	Laplace pressure ( $\Delta P_{Laplace}$ ), 20, 21
synthesis of Fe/Ni catalyst particles	liquid-liquid interface curves, 20f
(Chiang & Sankaran), 49	parallel multiphase microflows,
synthesis of MoO2 nanoparticles with	equation, 21
UHF, 50-51, 50f	pressure difference ( $\Delta P_{Flow}$ ), 20
synthesis of photoluminescent silicon	two-phase microflows, 16-19, 17f
nanocrystals by VHF, 49, 50f	viscosity of solvents at 20°C, 22t
synthesis of silicon nanoparticles	Plasma chemistry/technology
(Sankaran), 48, 49f	electrokinetic transport of cahrges, forms
UHF technique in MWCNTs, 51	DEP, 39
Nanotechnology, 40	electroosmosis, 39
Nanowires, applications, 47	electrophoresis, 39
Nelder-Mead simplex procedure, 216	EWOD, 39
Nitrite conversion to oxime, 189, 189f	industrial/commercial, examples
Noise-free optimization, technique	atmospheric pressure plasmas,
standard simplex method, 215, 215f, 216f	examples, 39
"adaptive simplex" approach, 215, 217f	low-pressure discharge, examples, 38–39
"reflective-simplex" approach,	Plasma-enhanced chemical vapor deposition
advantages, 215, 216f	(CVD), 38–39
statistical simplex approach, 218, 219f	Plasma state (fourth state of matter), 41
simultaneous optimization of peak	Point electrodes, 63, 66
emission wavelength and intensity,	Positioning/trapping of particles/molecules,
220, 221f	77–81
"Numbering up" principle, 54	Pressure-driven flow, 6, 74, 79, 81, 114, 150f, 164, 175
Oligosaccharides, continuous flow synthesis,	Pristane, continuous flow synthesis, 184-185,
119–120, 119f	185f
Oxomaritidine, flow-assisted synthesis, 188f	Protein adsorption
	Derjaguin-Landau-Verwey-Overbeek
PABA. See P-aminobenzoic acid (PABA)	theory, 92
p-Aminobenzoic acid (PABA), 91	orientation, experimental study
Paschen curve, 45, 46f	atomic force microscopy, 92
PASSflow reactors, 148	SIMS, 92
PDMS microreactor, reactions conducted in,	orientation, theoretical study
154f-155f	continuum models, 91-92
PEEK <sup>TM</sup> tube, 12	molecular models, 91
Photochromism by diarylethenes, 176f	reversible and nonspecific, 89-90

Protein microarrays, 90 Pulsed electric fields, 84

QDQW. See Quantum-dot quantum-well (QDQW)

Quantum-dot quantum-well (QDQW), 203–204

Radiolabel 2-[<sup>18</sup>F]-fluorodeoxyglucose (2-[<sup>18</sup>F]-FDG), synthesis of, 185f Reference materials (RMs), 227 Reynolds (Re) number, 15 Rimonabant, continuous flow synthesis, 180f RMs. *See* Reference materials (RMs)

SAM. See Self-assembled monolayer (SAM) SAUFs. See Single attribute utility functions (SAUFs)

"Scale-out" process, 228 Self-assembled monolayer (SAM), 26, 91, 93 Serpentine, 225, 226f

Simplex method, 215, 216f. See also Noise-free optimization, technique Simulated moving bed (SMB), 70, 75

Single attribute utility functions (SAUFs), 220 SMB. *See* Simulated moving bed (SMB)

Sonogashira C–C coupling reactions, 113 superheated water as reaction solvent, model reaction, 113f

Spindt type field emitter, 47, 47f Spiro lactone derivative, continuous flow synthesis, 174f, 175t

Stabilization methods, multiphase microflows

chemical surface modification, 25. See also Chemical surface modification methods extraction processes

microscopic quasielastic laser scattering method, 31

microcountercurrent flow patterns, 27, 29f liquid–liquid flows, 29, 30f

plug flow to two-phase microflows, conversion, 27, 29f, 31–32

shape of the liquid-liquid interface in a microchannel, 25, 26f

structure alteration, use of pillar structure, 25 Supercooled microflows, 118–119, 118f "Supersaturation" concentration, 197 Suzuki–Miyaura reaction, 114, 114f, 116, 145, 147

Synthesis of aminonaphthalene derivative, 132, 132f

Synthesis of diarylethenes (symmetrical/ unsymmetrical), 177f

Synthesis of oligosaccharides, continuous flow, 119–120, 119f

Thermal control by MRT

increased reaction temperature and pressure

copper-free Sonogashira C–C coupling reactions, 113

dehydration of  $\beta$ -hydroxyketones, 112, 112f

hydrolysis free O-acylation of alcohols, 114, 114f

Kolbe–Schmitt synthesis of 2,4-dihydrobenzoic acid from resorcinol, 112, 112f

microwave irradiation, alternative heat source. *See* Microwave-assisted reactions

synthesis of  $\alpha$ -aminophosphonates, 111, 111f

reduced reaction temperatures alkylation of N-acyl oxazolidinone, 117, 117f

continuous flow synthesis of oligosaccharides, 119–120, 119f

decomposition of enolate, batch conditions, 117–118, 118f

supercooled microflows application, scheme, 118, 118f

Thermal lens microscope (TLM), 6f, 8, 12

TLM. See Thermal lens microscope (TLM)
TMSCN. See Trimethylsilyl cyanide
(TMSCN)

Toxic/hazardous reagents in MRT continuous flow hydrosilylations using tris(trimethylsilyl)silane, 121t

exothermic reactions

Paal-Knorr synthesis, 135

fluorinations

of β-diketoester using elemental fluorine, 122, 122f

in small organic molecules (Miyake and Kitazume), 123, 126f substrates fluorinated by PTFE reactor (Gustafsson), 123, 124t trifluoromethylation of carbonyl compounds, 123, 125t nitrations of aromatics, 132-133 autocatalytic nitration of phenol, 133, 133f of salicylic acid, reaction products, 133-134, 134f selective nitration under flow by DSM, 134, 134f trimethylaluminum, 127, 128t tris(trimethylsilyl)silane-mediated deoxygenation/dehalogenation reactions, 120-121 use of butyllithium in microreactors anionic polymerizations under continuous flow, molecular weight effects, 131t benzophenone reactions in two-stage microreactor, 129 deprotonation of styrene oxide, reaction products, 131t monomer/initiator ratio, linear relation, 132 one-step coupling of fenchone/2bromopyridine. See Fenchone/2-

bromopyridine, one-step coupling

organometallics addition to benzophenone, 128f synthesis of aminonaphthalene derivative, 132, 132f Trifluoromethylation of carbonyl compounds, 123, 125t Trimethylaluminum, 127, 128t Trimethylsilyl cyanide (TMSCN), 143 Two-phase microflows, 16–19, 17f velocity profiles calculations, 18–19, 19f

UHF. See Ultrahigh frequency (UHF) Ultrahigh frequency (UHF), 50 Utility function, 212 UV photopatterning method, 27, 28f

"Viscous fingering," 74
VOCs. See Volatile organic compounds
(VOCs)
Volatile organic compounds (VOCs), 53

Wettability-based microvalve, 32–33, 32f Wittig–Horner olefination, 115, 182

Young-Laplace equation, 21 Y-shaped microfluidic device, design, 201, 201f residence time calculation, 201

Zeta potential, 73, 227, 228