Index

AATCC Test Method 118–2002, surface-modified fibers, 224
Absorption properties, optically variable pigments, 389
ABS plastic strip, 2,4,6-Trinitrotoluene (TNT), fingerprint analysis, 180–181
Accelerant analysis, multivariate statistical techniques, 359–360
“Accelerated aging” approach, ink analysis, 67–69
Accurate Arms 3100 smokeless powder: FTIR spectrum, 261–262
GS/MS spectrum, 263–264
AccuTOF spectrometer, Direct Analysis in Real Time (DART) mass spectrometry, 176
Achromatic colors, optically variable pigments, 388
Active® Glass, surface-modified fibers, scanning electron microscopy/energy dispersive spectroscopy, 231–232
Additive color theory, optically variable pigments, 383–385
Additive mixing, optically variable pigments, color blending, 382–383
Adhesives, pressure-sensitive tapes, 296–298
duct tape, 300–307
homicide case study, 327–329
masking tape, 315–316
polarized light microscopy analysis, 325–326
Accelerant analysis, multivariate statistical techniques, 359–360
“Accelerated aging” approach, ink analysis, 67–69
Accurate Arms 3100 smokeless powder: FTIR spectrum, 261–262
GS/MS spectrum, 263–264
AccuTOF spectrometer, Direct Analysis in Real Time (DART) mass spectrometry, 176
Achromatic colors, optically variable pigments, 388
Active® Glass, surface-modified fibers, scanning electron microscopy/energy dispersive spectroscopy, 231–232
Additive color theory, optically variable pigments, 383–385
Additive mixing, optically variable pigments, color blending, 382–383
Adhesives, pressure-sensitive tapes, 296–298
duct tape, 300–307
homicide case study, 327–329
masking tape, 315–316
polarized light microscopy analysis, 325–326
Aggregation materials, cathodoluminescence, 168
Alexander v. State, glitter as evidence in, 24–31
Alliant Powder Power Pistol characterization, 253–256
Aluminum compounds, cathodoluminescence, feldspar group, 159–160
5-Aminotetrazole, automotive airbags, 35
Amphetamines, multivariate statistical analysis, 362
Analysis of variance (ANOVA):
multivariate statistical analysis, 354–359
optically variable pigments, 395
Analyte target molecules:
fabric color analysis, 211–214
ink analysis, 63–64
Anatase, cathodoluminescence, 168–171
Animal products, stable isotope ratio analysis, 411–414
Anionic dyes:
fabric color analysis, ESI-MS techniques, 204–207
ink analysis, 69–71
Anthropogenic materials, cathodoluminescence, 168–171
cement and concrete, 168
duct tape, 170–171
glass, 169
paint, 170
slag, fly ash, and bottom ash, 168–169
Antimalaria mosquito nets, gas chromatography/mass spectrometry analysis, 234
Antioxidants, condom trace evidence, 86 case studies, 108–111
Apatite, cathodoluminescence, 163
Aragonite, cathodoluminescence, 156–158
Area measurement, optically variable pigments, 392
Aromas, condom trace evidence, 87
Arson accelerants, Direct Analysis in Real Time (DART) mass spectrometry, 188–189
Art forgeries, ink analysis, 74–75
Associative evidence, fibers as, 221–222
Atmospheric pressure chemical ionization (APCI) techniques, fabric color analysis, 203–204
liquid chromatography-mass spectrometry comparisons, 211–214
mass spectral analysis protocol, 216–217
Attenuated total reflectance (ATR):
document examination and currency analysis, 360–362
glitter characterization:
criminal case studies of, 25–31
infrared spectroscopy (FTIR), 15–19
Raman microspectroscopy, 19–22
surface-modified fibers, 223
Attenuated total reflectance/Fourier transform infrared spectroscopy (ATR/FTIR):
fiber analysis, 362–364
pressure-sensitive tapes, 320–324
smokless powder identification, 242
brand identification, 261–262
Authentication procedures, cathodoluminescence, 166
Automotive accident investigations:
airbags forensic analysis and, 39–54
glitter as evidence in, 30–31
hit and run accidents, glass cuts in, 274–276
Automotive airbags:
equipment and technology, 34–35
forensic analysis:
applications, 33–34
case reports and examples, 39–54
classification, 35–39
design and manufacturing changes, 54–55
future research issues, 55
history of, 34
Autoscaling:
multivariate statistical analysis, 341–342
principal component analysis, 344–348
Azo dyes:
fabric color analysis, 211–214
pepper spray detection, 133–138
Background correction, multivariate statistical analysis, 338–342
Background fluorescence, latent bloodstains, 118–125
Backing materials:
masking tape, 315–316
pressure-sensitive tape, 296–297
electrical tape, 307–309
pressure-sensitive tapes, polarized light microscopy analysis, 325–326
Backscatter electron (BSE) imaging, cathodoluminescence, calcium carbonate, 158
Backsize materials, pressure-sensitive tape, 294–295
Ballpoint pens, ink analysis, 63–64 laser desorption mass spectrometry, 64–74
Ball powder morphology, smokeless powder characterization, 248–249
Band gap energy, cathodoluminescence, 144–147
Baseline corrections, multivariate statistical analysis, 339–342
Ballistic uniforms (BDUs), gas chromatography/mass spectrometry analysis, 234
Beam intensity, cathodoluminescence spectral collection, 154
Beer’s law, cathodoluminescence, 147
Biaxially oriented polypropylene (BOPP), polypropylene packaging tape, 310–313
Bis(carbocyanines), latent trace analysis, fingerprints, 127–130
Bis(Heptamethine Cyanine) (BHmC), latent trace analysis, fingerprints, 129–130
Blade characteristics, glass cut analysis, 280–281
Bleached fabrics, pepper spray detection, 134–138
Blending technology, optically variable pigments, 388
Block copolymers, pressure-sensitive tapes, adhesive formulas, 297–299
Bloodstains:
automotive airbag forensics, 39–54
latent detection, 117–125
tearing patterns in fabric, 278–279
Body fluids, Direct Analysis in Real Time (DART) mass spectrometry, 181–182
Bone materials, stable isotope ratios, 413–414
Bottom ash, cathodoluminescence, 168–169
Butylated hydroxytoluene (BHT), condom lubricant residue analysis, case studies, 108–111
BUZZ OFF™ fabrics, gas chromatograph/mass spectrometry, 232–234
Calcite, cathodoluminescence, 156–158
Calcium carbonates, cathodoluminescence, 156–158
Calibration standards, optically variable pigment measurements, 392–393
Camera equipment, cathodoluminescence, 149–150
Canister powders:
brand identification, 243, 247–257
improvised explosive devices, 241–242
Canonical variates (CVs):
drug analysis, 362
linear discriminant analysis, 349–354
Capillary column gas chromatography, surface-modified fibers, 238
Capillary electrophoresis (CE), fiber color analysis, 199–203
Capsaicinoid molecules, pepper spray detection, 130–138
CAP-STUN pepper spray, latent trace evidence, 130–138
Carbonate materials, cathodoluminescence, 156–158
Carbon isotope ratios:
drugs of abuse, 408–411
food product authenticity and adulteration, 407–408
human bone, hair, and teeth, 413–414
Carpet fibers:
arson accelerants, Direct Analysis in Real Time (DART) mass spectrometry, 188–189
color analysis, capillary electrophoresis, 199–203
Car theft, automotive airbag forensics, case studies, 39, 46–54
Cathode configurations, 144
  hot and cold configurations, 147–149
  sample preparation and preservation, 152–153
  spectral collection, 153–154
Cathodoluminescence (CL):
  anthropogenic materials, 168–171
  cement and concrete, 168
duct tape, 170–171
  glass, 169
  paint, 170
  slag, fly ash, and bottom ash, 168–169
camera equipment, 149–150
deefined, 141–143
electron source, 143–144, 147–149
forensic applications, 164–166
  authentication, 166
  identification, 165
  provenance, 166
  screening and application, 165
future applications and research, 171
geological soil and sand samples, 167
instrumentation, 147–150
limitations, 147
mechanisms, 144–147
microscope selection, 149
mineral sources, 156–164
  accessory minerals, 163–164
  calcium carbonate group, 156–158
  feldspar group, 159–160
  quartz, 160–163
SEM-CL spectrometers, 150
spectrometer, 150
techniques and forensic analysis,
  151–156
  image collection, 153
  instrumental conditions, 151–152
  luminescence fading, 155
  sample alteration, 155–156
  sample preparation and preservation, 152–153
  spectral collection, 153–154
terminology, 143
type, 143
Cationic dyes:
  fabric color analysis, ESI-MS techniques, 204–207
  ink analysis, 65–66, 69–71
Cement, cathodoluminescence, 168
Charge-coupled device (CCD) camera:
  cathodoluminescence, 150
  image collection, 153
latent trace analysis, fingerprints, 126–130
Chemical characteristics:
  condom trace evidence, 95–106
of glitter, 5
multivariate statistical analysis:
  accelerants, 359–360
  data patterns, 333–336
  document examination and currency analysis, 360–362
  drug analysis, 362
  experimental design and preprocessing, 336–342
  fibers, 362–364
glass, 364
group separation, classification accuracy, and outlier detection, 354–359
  linear discriminant analysis, 348–354
  principal component analysis visualization, 342–348
  trace minerals, 364–366
  pepper spray detection, 133–138
trace evidence visualization and imaging, 116–117
Chemical warfare agents, Direct Analysis in Real Time (DART) mass spectrometry, 189–190
Chi-squared analysis, optically variable pigments, 395
Chlorine atoms, ink analysis, 72
Chromatic absorbing pigments, optically variable pigment blending, 388
Chromaticity values, optically variable pigments, color matching functions, 381–382
diagram for, 385–386
Chromatographic separation protocol:
  fiber color analysis, 216
multivariate statistical analysis, 334–336
CIE 1931 Standard Colorimetric System, optically variable pigments, color measurement, 380
chromaticity diagram, 385–386
Class evidence, glitter as, 3–8
Classification accuracy, multivariate statistical analysis, 354–359
CL-20 compound, Direct Analysis in Real Time (DART) mass spectrometry, 188
C18 liquid chromatography, fabric color analysis, 211–214
Coating materials:
lubricant coatings, condom trace evidence:
Direct Analysis in Real Time (DART) mass spectrometry, 182–184
forensic analysis, 104–105
materials characterization, 87
residue analysis, 92–96
pressure-sensitive tapes:
primer coat, 296
release coat, 293–294
Cocaine, stable isotope ratio analysis, 408–411
Codeine, Direct Analysis in Real Time (DART) mass spectrometry, 178–179
Collection techniques, glitter traces, 8–9
Collision energy (CE), fiber color analysis, 209–210
Collision induced dissociation (CID), fabric color analysis, 204–205
structural elucidation, 208–210
tandem mass spectrometry, 215–216
Colorants:
ink analysis, 63–64
laser desorption mass spectrometry, 75–76
optically variable pigments, 376–379
blending technologies, 382–383
pressure-sensitive tapes:
backing materials, 296–297
duct tape, 299–307
Color matching functions, optically variable pigments, 380–382
Color properties:
fiber dyes, 200–203
smokeless powder, 257–258
Color shift pigments, peroperties, 378–379
Concentration analysis, glitter traces, 8–9
Concrete, cathodoluminescence, 168
Condom trace evidence:
Direct Analysis in Real Time (DART) mass spectrometry, 182–184
forensic evaluation, 96–105
forensic significance, 81–82
lubricant coating:
production, sale, and use, 87
residues, 92–96
packaging characteristics, 106–111
physical examination protocols, 96–105
powdering process:
production, sale, and use, 86–87
residues, 88–92
production, 85–86
residue traces, 88–96
rough condom vulcanization:
production, 85–86
residues, 88, 99–101
sales and market share and, 82–84
sexual crimes and usage patterns, 83–84

CIE 1931 Standard Colorimetric System, optically variable pigments, color measurement, 380
chromaticity diagram, 385–386
Class evidence, glitter as, 3–8
Classification accuracy, multivariate statistical analysis, 354–359
CL-20 compound, Direct Analysis in Real Time (DART) mass spectrometry, 188
C18 liquid chromatography, fabric color analysis, 211–214
Coating materials:
lubricant coatings, condom trace evidence:
Direct Analysis in Real Time (DART) mass spectrometry, 182–184
forensic analysis, 104–105
materials characterization, 87
residue analysis, 92–96
pressure-sensitive tapes:
primer coat, 296
release coat, 293–294
Cocaine, stable isotope ratio analysis, 408–411
Codeine, Direct Analysis in Real Time (DART) mass spectrometry, 178–179
Collection techniques, glitter traces, 8–9
Collision energy (CE), fiber color analysis, 209–210
Collision induced dissociation (CID), fabric color analysis, 204–205
structural elucidation, 208–210
tandem mass spectrometry, 215–216
Colorants:
ink analysis, 63–64
laser desorption mass spectrometry, 75–76
optically variable pigments, 376–379
blending technologies, 382–383
pressure-sensitive tapes:
backing materials, 296–297
duct tape, 299–307
Color matching functions, optically variable pigments, 380–382
Color properties:
fiber dyes, 200–203
smokeless powder, 257–258
Color shift pigments, properties, 378–379
Concentration analysis, glitter traces, 8–9
Concrete, cathodoluminescence, 168
Condom trace evidence:
Direct Analysis in Real Time (DART) mass spectrometry, 182–184
forensic evaluation, 96–105
forensic significance, 81–82
lubricant coating:
production, sale, and use, 87
residues, 92–96
packaging characteristics, 106–111
physical examination protocols, 96–105
powdering process:
production, sale, and use, 86–87
residues, 88–92
production, 85–86
residue traces, 88–96
rough condom vulcanization:
production, 85–86
residues, 88, 99–101
sales and market share and, 82–84
sexual crimes and usage patterns, 83–84
silicone treatment, production, sale, and use, 86
usage patterns and, 82–84
Confirmatory analysis, pepper spray detection, 136–138
Confiscated sample characteristics, drug/pharmaceutical analysis, Direct Analysis in Real Time (DART) mass spectrometry, 178
Confocal depth mapping, glitter characterization, 20–22
ContactIR device, glitter characterization, 17–19
Contact trace evidence: automotive airbags:
applications, 33–34
case reports and examples, 39–54
classification, 35–39
future research issues, 55
manufacturing changes, 54–55
case studies, 105–111
CRAIC 1000 microspectrophotometer, automotive airbag forensics, 46–54
Criminal case studies, glitter as evidence in, 24–25
Cross polarization techniques, condom powdering residue analysis, 88–91
Cross sectioning techniques, glitter characterization, 15–16
Cross-validation, multivariate statistical analysis, 357–359
Crystal field strength, cathodoluminescence, 145–146
Crystallina 321/421 systems, glitter characterization, 20–22
Crystal violet, ink analysis, 66–69
Currency analysis:
multivariate statistical analysis, 360–362
pack dyes, Direct Analysis in Real Time (DART) mass spectrometry, 185
Cutting machine characteristics, glitter, 6–8
Cyanoacrylate fuming, latent trace analysis, fingerprints, 126–130
Data partitioning, multivariate statistical analysis, 357–359
Data storage and analysis:
principal component analysis, 343–348
Daubert v. Merrill Dow Pharmaceuticals, Inc., 335
Delta notation, stable isotope ratio analysis, 401
food product authenticity and adulteration, 408
Derivatization reactions, pepper spray detection, 136–138
“Designer pens,” ink analysis, 71–72
Desorption/ionization methods: condom lubricant residue analysis, 92–96
case studies, 106–111
ink analysis, 59–62, 65–69
Diazon dyes, fabric color analysis, 211–214
Diazonium reagents, pepper spray detection, 136–138
Diethylene glycol dinitrate (DGDN), smokeless powder, 245
Diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS), condom lubricant residue analysis, 92–96
Dihydrocapsaicin, pepper spray detection, 136–138
Dimensionality reduction, multivariate data, 342–348
Dinitrotoluene (DNT), smokeless powder, 245
Dioctyl phthalate (DOP), electrical tape, 307–309
Diopside, cathodoluminescence, 163–164
Direct Analysis in Real Time (DART) mass spectrometry:
  arson accelerants, 188–189
  basic principles, 175–176
  body fluids, 181–182
  chemical warfare agents, 189–190
  condom lubricants, 182–184
  drug/pharmaceutical analysis, 177–180
  confiscated samples, 178
  endogenous drugs, 178–179
  surface residues, 179–180
  dyes, 184–185
  experimental applications, 176
  explosives, 185–188
  fibers, 192–193
  fingerprints, 180–181
  future research, 194
  glues, 191
  ink analysis, 193
  materials identification, elevated-temperature techniques, 190–191
  plastics, 191–192
  “Dirty crystals,” ink analysis, 61–62
Discontinuous cut patterns, glass cut analysis, 282–286
Disc-shaped smokeless powders, 253–256
Dithiocarbamates, condom residue analysis, 100
DNA analysis:
  automotive airbag forensics, 35–36, 45–54
  condom trace evidence, case studies, 106–111
  glitter characterization, criminal case studies, 30–31
  latent trace evidence, bloodstains, 124–125
Document examination, multivariate statistical analysis, 360–362
Dolomite, cathodoluminescence, 156–158
Dopant materials:
  Direct Analysis in Real Time (DART) mass spectrometry, explosives, 187–188
  stable isotope ratio analysis, 408–411
Drug abuse evidence:
  automotive airbag forensics, 43–54
  Direct Analysis in Real Time (DART) mass spectrometry, 177–180
  confiscated samples, 178
  endogenous drugs, 178–179
  surface residues, 179–180
  multivariate statistical analysis, 362
  stable isotope ratio analysis, 408–411
Drunk driving investigations, automotive airbag forensics, 39–54
Duct tape:
  cathodoluminescence, 170–171
  forensic analysis of, 299–307
  variability in, 291–292
DuPont IMR 4350 smokeless powder:
  FTIR spectrum, 261–262
  GS/MS spectrum, 264–265
Dyes. See also Pigments
  Direct Analysis in Real Time (DART) mass spectrometry, 184–185
Fabric analysis:
  basic principles, 197–198
  conventional comparison techniques, 198–199
  direct ESI-MS analysis, 204–207
  direct infusion MS/MS protocol, 214–216
  generalized LC-MS and LC-MS/MS protocol, 216–217
  ionization techniques, 203–204
  limitations of UV-VIS-based analysis, 199–203
liquid chromatography-mass spectrometry analysis, 210–214
negative ESI-MS analysis, 207–208
tandem mass spectrometry, 208–210
linear discriminant analysis, 349–354
optically variable pigments, 388
pressure-sensitive tapes, backing materials, 296–297

EA2192 agent, Direct Analysis in Real Time (DART) mass spectrometry, 189–190
Ecstasy, drugs of abuse, 410–411
Eigenvectors/eigenvalues:
  linear discriminant analysis, 352–354
  principal component analysis, 343–348
Elastomers, pressure-sensitive tapes, adhesive formulas, 297–299
Electrical tape, forensic analysis, 307–309
Electron beam interaction,
  cathodoluminescence, 143–144
  sources, 147–149
Electron capture detector (ECD),
  surface-modified fibers, 238
Electron hole pairs,
  cathodoluminescence, 144–147
Electron impact mass spectrometry (EIMS):
  ink analysis, 58–62
  smokeless powder identification,
    GS/MS spectrum, 264–265
  surface-modified fibers, pyrolysis gas chromatography/mass spectrometry, 237–238
Electron source, cathodoluminescence, 143–144
Electrospray ionization (ESI), fabric color analysis, 202–204
  liquid chromatography-mass spectrometry comparisons, 211–214
  mass spectral analysis protocol, 216–217
Electrospray ionization mass spectrometry (ESI–MS):
  fabric color analysis, 204–207
  negative ion analysis, nylon windings, 207–208
  quadrupole ion trap instrumentation, 211–214
  structural elucidation, 208–210
  pepper spray detection, 136–138
Elemental analysis:
  pressure-sensitive tapes, 320, 324–325
  sampling protocols, 317
  stable isotopes, 400–401
Elevated-temperature Direct Analysis in Real Time (DART) mass spectrometry, material identification, 190–191
End matching techniques, pressure-sensitive tapes, 318–319
Energy dispersive spectroscopy (EDS). See also Scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS)
  surface-modified fibers, pyrolysis gas chromatography/mass spectrometry, 235–238
Energy dispersive x-ray analysis (EDXA):
  glitter analysis, 22–23
  criminal case studies, 25–31
  optically variable pigments, 395
Enzyme-linked immunosorbent assay (ELISA), condom residue analysis, 88
Ethanol acetic acid, latent bloodstain analysis, 120–125
Ethylene glycol dinitrate (EGDEN), Direct Analysis in Real Time (DART) mass spectrometry, 187–188
Euclidean distance, multivariate statistical analysis, 355–359
Explosives:
  Direct Analysis in Real Time (DART) mass spectrometry, 185–188
  smokeless powders:
    ATR-FTIR spectroscopy, 261–262
    basic properties and classification, 241–242
    brand determination, 242–243, 246–257
    ball-shaped powders, 248–249
disc shaped powders, 253–256
flattened ball powders, 256–257
lamella shaped powders, 258
tubular powders, 249–253

color, 257–258
Fourier Transform infrared spectroscopy, 260–262
gas chromatograph/mass spectrometry, 262–265
historical background, 243–245
identification, 242, 245–246
kernel/dot configuration, 258
liquid chromatography, 265–266
luster, 258
mass, 259–260
micrometry, 258–259
micromorphology, 247–257
morphology, 246–247
transmission micro-FTIR, 260–261
stable isotope ratios, 414–416

Extrinsic luminescence, cathodoluminescence and, 145–147

Fabric analysis. See also Fiber analysis
Direct Analysis in Real Time (DART) mass spectrometry, carpet remnants, 188–189
dyes:
 basic principles, 197–198
conventional comparison techniques, 198–199
direct infusion MS/MS protocol, 214–216
ESI-MS analysis, 204–207
generalized LC-MS and LC-MS/MS protocol, 216–217
ionization techniques, 203–204
limitations of UV-VIS-based analysis, 199–203
liquid chromatography-mass spectrometry analysis, 210–214
negative ESI-MS analysis, 207–208
tandem mass spectrometry, 208–210
pepper spray detection, 134–138
pressure-sensitive tapes, reinforcement materials, 296, 299–307
Fading phenomena, cathodoluminescence, 154
Fast atom bombardment (FAB), ink analysis, 59–62
Feldspar group, cathodoluminescence, 159–160
Fiber analysis. See also Fabric analysis
automotive airbag forensics, 35–36, 47–54
Direct Analysis in Real Time (DART) mass spectrometry, low-mass fragments, 192–193
duct tape reinforcement, 300–304
glass cuts in:
 associated glass fragments, 280
 basic principles, 269–270
 blade characteristics, 280–281
direction changes, 286
discontinuous cuts, 282–286
fabric properties, 280
hit and run accident case study, 274–276
homicide case study, 270–271
leather cuts, 287
parallel cuts, 286
recent or worn damage, 286–287
robbery case study, 271–274
slash cuts, 279–280
tearing vs. cutting, 276–279, 281–282
linear discriminant analysis, 349–354
multivariate statistical analysis, 339–342, 362–364
principal component analysis, dimensionality reduction, 343–348
surface-modified characterization:
distinguishing tests, 225
gas chromatography/mass spectrometry, 231–234
preliminary examinations, 222–224
pyrolysis gas chromatography/mass spectrometry, 234–238
research background, 221–222
scanning electron microscopy/energy dispersive spectroscopy, 225–231
structural properties, 222
Filament tape, forensic analysis, 313–315
“Fingerprint” electropherograms, fiber color analysis, 199–203
collision-induced dissociation, 209–210
INDEX

Fingerprints:
  Direct Analysis in Real Time (DART) mass spectrometry, 180–181
  latent trace analysis:
    fluorescein testing, 119–125
    near-infrared dyes, 125–130
Firearms, smokless powder, history, 243–245
Fisher ratio plot, linear discriminant analysis, 352–354
Flake construction diagram, optically variable pigments, 376–379
Flattened ball smokeless powder, 256–257
Flavorings, condom trace evidence, 87, 95
Fluorescein testing, latent trace evidence, bloodstains, 117–125
Fluorescence. See also Luminescence defined, 143
  latent trace evidence, fluorescein interference, 124–125
Fluorescence microscopy:
  masking tape forensics, 316
  multivariate statistical analysis, fibers, 362–364
Fly ash, cathodoluminescence, 168–169
Food products, authenticity and adulteration, stable isotope ratio analysis, 406–408
Fourier self-deconvolution (FSD), condom lubricant residue analysis, 104–105
Fourier transform infrared spectroscopy (FTIR):
  amphetamines, 362
  condom lubricant residue analysis, 92–96, 104–105
  case studies, 106–111
  document examination and currency analysis, 360–362
  fabric dye analysis, 214
  glitter characterization:
    criminal case studies, 30–31
    cross sectioning techniques, 15–19
    polypropylene packaging tape, 313
    pressure-sensitive tapes, 320
    duct tape, 305–307
  electrical tape, 307–309
  homicide case study, 327–329
  masking tape, 316
  sampling protocols, 317
  smokeless powder characterization, 260–262
  surface-modified fibers, 223–224k
  Fourier Transform mass spectrometry (FTMS), ink analysis, 60–62
  Fragment analysis, associated glass, with glass cuts, 280
  Franck-Condon absorption bands, fiber dye analysis, 202–203
  Fraud detection, ink analysis, 74–75
  Frye v. United States, 335
  F test, optically variable pigments, 395
Gamut of colors, optically variable pigments, creation of, 386–387
Gas chromatography (GC):
  multivariate statistical analysis, 341–342
  smokeless powder identification, 242
  splitless injectors, 262–266
Gas chromatography/mass spectrometry (GC/MS):
  accelerant analysis, 359–360
  amphetamines, 362
  condom lubricant residue analysis, 93–96, 104–105
  case studies, 108–111
  document examination and currency analysis, 360–362
  fiber analysis, 363–364
  latent trace evidence, pepper spray analysis, 130–138
  smokeless powder identification, 262–266
  surface-modified fibers, 231–234
Gas leakage, automotive airbags, 37–39, 52–54
Geological samples, cathodoluminescence:
  provenance criteria, 166
  quartz, 162–163
  soil and sand characterization, 167
Geometric measurements, optically variable pigments, 390–391
Germany, condom market share in, 82–83
Glass:
cathodoluminescence, 169
cuts, as trace evidence:
  associated glass fragments, 280
  basic principles, 269–270
  blade characteristics, 280–281
direction changes, 286
discontinuous cuts, 282–286
  fabric properties, 280
hit and run accident case study, 274–276
homicide case study, 270–271
leather cuts, 287
parallel cuts, 286
recent or worn damage, 286–287
robbery case study, 271–274
slash cuts, 279–280
tearing vs. cutting, 276–279, 281–282
multivariate statistical analysis, 364
Glass transition temperature, polypropylene packaging tape, 310–313
Glitter:
  characterization methods, 10–24
  color, 11–12
cross sectioning, 15–16
infrared spectroscopy, 16–19
morphology, 12–13
Raman microspectroscopy, 19–22
scanning electron microscopy/energy dispersive spectroscopy, 22–24
shape, 13
size, 13–14
thickness, 14–1–5
components of, 1–2
contact trace properties, 210
  collection, separation and concentration, 8–9
  color, 5–6
computerized database capability, 9–10
cutting machine characteristics, 6–8
film and particle manufacturers, 6
individual characteristics, 3–8
invisibility, 2–3
layer characteristics, 4–5
morphology, 4
particle analysis, 9
size properties, 3
specific gravity, 4
structural characteristics, 3
transfer and retention, 3
transport vehicles for, 8
as criminal evidence, 24–31
ink analysis, 71–72
Glues, Direct Analysis in Real Time (DART) mass spectrometry, 191
Gonioappearance pigments, characteristics and function, 377–379
Graphical methods, optically variable pigment formulation, 385–386
Group membership classification, multivariate statistical analysis, 356–359
Guanidine nitrate (GuNi), automotive airbags, 35
Guncotton, smokeless powder history, 244–245
Gunpowder, history, 243–245
Guns. See Firearms
Gypsum, cathodoluminescence, 163–164
Hair analysis:
  automotive airbag forensics, 45–54
  stable isotope ratios, 413–414
Handling protocols, pressure-sensitive tape forensics, 316–317
Hematoxylene-eosine (HE) staining, condom powdering residue analysis, 88–91
Hercules Red Dot smokeless powders, 253–255
Hercules Reloder 12 tubular smokeless powder, 249–250
Heroin analysis, stable isotope ratio analysis, 408–411
Hexahydro-1,3-5-trinitro-1,3,5-triazine (RDX), Direct Analysis in Real Time (DART) mass spectrometry, 187–188
Hexamethylene triperoxide diamine (HMTD) explosive, Direct Analysis in Real Time (DART) mass spectrometry, 186–188

High-performance liquid chromatography (HPLC):
- document examination and currency analysis, 360–362
- fiber color analysis, 198–199, 203–204
- trace quantity extraction, 213–214
- oligonucleotide analysis, 76–77

Homicide cases:
- glass cuts as evidence in, 270–271
- glitter as evidence in, 24–31
- pressure-sensitive tapes, 327–329

Hotelling’s $T^2$ test, multivariate statistical analysis, 354–359

Human products, stable isotope ratio analysis, 411–414

Hydrocarbon contamination, cathodoluminescence spectral collection, 154

Hydrogen isotope ratios, animal and human products, 411–414

2-(4-Hydroxyphenylazo) benzoic acid (HABA), oligonucleotide analysis, 75–76

Identification techniques, cathodoluminescence, 165

Illuminants, optically variable pigments, color measurement, 380

IlluminatIR Infrared Microspectrometer, glitter characterization, 17–19

Image collection, cathodoluminescence, 153

Improvised explosive devices (IEDs):
- Direct Analysis in Real Time (DART) mass spectrometry, 186–188
- pressure sensitive tape for, 291
- smokless powders, 241–242
  - brand identification, 242–243, 247–257
- IMR 4198 smokeless powder, 250–252

Indigotin dyes, fiber color analysis, mass spectrometry analysis, 214

Individualistic properties of evidence, glitter, 3–8

Inductively couple plasma (ICP):
- glass analysis, 364
- pressure-sensitive tapes, 324–325

Infrared spectra:
- glitter characterization, 16–19
- surface-modified fibers, 223

Ink analysis:
- analyte target molecules, 63–64
- Direct Analysis in Real Time (DART) mass spectrometry, 193
- laser desorption mass spectrometry (LDMS), 58–62

Inorganic pigments, ink analysis, 72–74

Insecticide-treated clothing, gas chromatography/mass spectrometry analysis, 232–234

Interference pigments, measurement of, 394

Internal reflectance element (IRE), pressure-sensitive tapes, 320–324

International Atomic Energy Agency (IAEA) standard, stable isotope ratio analysis, 401

Intrinsic luminescence, cathodoluminescence and, 144–147

Invisibility properties, glitter, 2–3

Ionization techniques, fabric color analysis:
- ESI-MS techniques, 204–207
- liquid chromatography-mass spectrometry and, 211–214

Iron compounds, cathodoluminescence:
- calcium carbonates, 157–158
- feldspar group, 159–160

ISA/SPEX MiniCrime-Scope, latent trace analysis, fingerprints, 126–130

Isotope rationing mass spectrometry (IRMS):
- manufactured items, 414–416
- stable isotope ratio analysis, 403

“Isotopic peaks,” ink analysis, 65–69

JASCO NRS-3100 Raman system, glitter characterization, 20–22

Kava starch grains, condom powdering residue analysis, 90–91
Kevlar fibers, multivariate statistical analysis, 339–342
Kidnapping cases, glitter as evidence in, 26–31
Kinetic energy:
  ink analysis, 61–62
  stable isotope ratio analysis, 401–402
Knife cuts, glass cuts compared with:
  homicide case studies, 270–271
  robbery case study, 271–274
  tearing patterns in fabric, 277–279
Known sample (K):
  glitter characterization and, 10–24
    color analysis, 11–12
    particle size, 13
    surface-modified fibers, 222–224
    pyrolysis gas chromatography/mass spectrometry, 234–238
  Kumho Tire Co. v. Carmichael, 335–336
Lactones, latent bloodstain analysis, 118–125
Lamella powders, smokeless powder characterization, 248
Laser ablation inductively coupled plasma mass spectrometry
  (LA-ICP-MS), cathodoluminescence, glass materials, 169
Laser desorption mass spectrometry (LDMS):
  basic principles, 57–58
  failures of, 75–76
  ink analysis, 58
    analyte target molecules, 63–64
    fraud applications, 74–75
    pen ink dyes, 64–74
    instrumentation, 59–62
Latent invisible trace evidence:
  bloodstains, 117–125
    method overview, 123–125
    chemical detection principles, 115–117
  fingerprint detection, near-infrared dyes, 125–130
  pepper spray, 130–138
    chemical derivatization, 134–138
    near-infrared dyes, 131–133
Latex proteins, condom trace evidence, 85
  forensic analysis, 99–101
  residue analysis, 88
Layer thickness and numbers, of glitter, 4–5
Leather, glass cut analysis on, 287
Leave-one-out cross validation,
  multivariate statistical analysis, 357–359
Length measurements, tubular smokeless powder identification, 252–253
Leuco fluorescein:
  latent bloodstain analysis, 118–125
  latent trace evidence, disadvantages of, 124–125
Light-emitting diode (LED) lamps:
  latent trace analysis:
    bloodstains, 120–125
    fingerprints, 126–130
    pepper spray, 132–138
    optically variable pigments, color blending, 382–383
Light source stability, optically variable pigment measurements, 393
Linear discriminant analysis (LDA):
  accelerant forensics, 359–360
  development and application, 336
  document examination and currency analysis, 360–362
  drug analysis, 362
  fibers, 362–364
  glass analysis, 364
  group difference visualization, 348–354
  mineral trace evidence, 365–366
Linear measurements, smokeless powder, 259
Liquid chromatography (LC):
  fabric dye analysis, 203–204
  smokeless powder identification, 242, 262–266
Liquid chromatography/mass spectrometry (LC/MS):
  condom lubricant residue analysis, 93–96
  fabric color analysis, US-Vis spectrometry, 202–203
  fiber color analysis, 210–214
    generalized protocol, 216–217
latent trace analysis, pepper spray analysis, 132–138
Liquid chromatography-tandem mass spectrometry (LC-MS/MS), fiber color analysis, generalized protocol, 216–217
Locard’s Principle of Exchange, automotive airbags forensics, 33–34
Location characteristics, glitter traces, 9
Long tubular smokeless powders, identification, 250–252
Low density polyethylene (LDPE), duct tape analysis, 299–307
Lubricant coatings, condom trace evidence:
Direct Analysis in Real Time (DART) mass spectrometry, 182–184
forensic analysis, 104–105
materials analysis, 87
residue analysis, 92–96
Lugol’s solution, condom powdering residue analysis, 89–91
Luminescence:
basic technology, 143
cathodoluminescence:
anthropogenic materials, 168–171
cement and concrete, 168
duct tape, 170–171
glass, 169
paint, 170
slag, fly ash, and bottom ash, 168–169
camera equipment, 149–150
defined, 141–143
electron source, 143–144, 147–149
fading phenomena, 154
forensic applications, 164–166
authentication, 166
identification, 165
provenance, 166
screening and application, 165
geological soil and sand samples, 167
instrumentation, 147–150
limitations, 147
mechanisms, 144–147
microscope selection, 149
minerals characterization, 156–164
accessory minerals, 163–164
calcium carbonate group, 156–158
feldspar group, 159–160
quartz, 160–163
SEM-CL spectrometers, 150
spectrometer, 150
techniques and forensic analysis, 151–156
image collection, 153
instrumental conditions, 151–152
luminescence fading, 155
sample alteration, 155–156
sample preparation and preservation, 152–153
spectral collection, 154–155
terminology, 143
theory, 143
gem authentication, 166
mechanisms, 144
Luminol, latent trace evidence, bloodstains, 117–125
Luminescope ELM-3R instrumentation, cathodoluminescence, 151–152
Luster properties:
optically variable pigments, 376–379
smokeless powder, 258
Lycopodium spores, rough condom powdering:
forensic analysis, 103
materials characterization, 86
residue analysis, 91–92
Machine edge characteristics,
polypropylene packaging tape, 313
Magnesium compounds,
cathodoluminescence, 146–147
calcium carbonates, 157–158
Magnification, optically variable pigments, 391–392
Mahalanobis distance, multivariate statistical analysis, 355–359
Manganese compounds,
cathodoluminescence, 146–147
calcium carbonates, 157–158
feldspar group, 159–160
Manufacturers’ sources:	glitter, 6
pressure-sensitive tapes:
equipment markings, 297
identification, 326–327
stable isotope ratios, 414–416
Marijuana, Direct Analysis in Real Time (DART) mass spectrometry, 178–179
Masking tape, forensic analysis, 315–316
Mass measurements, smokeless powder, 259–260
Mass spectrometry (MS):
fabric color analysis, 202–204
electrospray ionization and, 204–208
generalized protocol, 216–217
glass analysis, 364
instrumentation, 58–62
latent trace analysis, pepper spray analysis, 132–138
pepper spray detection, 133–138
smokeless powder identification, 242, 262–266
stable isotope ratio analysis, 402–403
Material inhomogeneity, optically variable pigment measurements, 393–394
Matrix-assisted laser desorption time-of-flight (MALDI-TOF) mass spectrometry:
condom trace evidence:
case studies, 108–111
spermicide residue analysis, 95–96
ink analysis, 57–62
oligonucleotide analysis, 75–76
MCS-400 MiniCrimeScope light source, latent trace analysis, 122–125
pepper spray analysis, 132–138
Mean centering:
multivariate statistical analysis, 341–342
principal component analysis, 343–348
Measurement techniques:
cathodoluminescence spectra, 153–154
color measurement, optically variable pigments, 379–382
optically variable pigments, uncertainty levels, 392–393
pressure-sensitive tape forensics, 319
smokeless powder, 252–253, 259–260
Mercury isotopes, ink analysis, 73–74
Metallic colors, additive color theory, 383–385
1-Methylaminoanthraquinone (MAAQ), Direct Analysis in Real Time (DART) mass spectrometry, 185
Methyl violet dyes, ink analysis, 66–69
Mica-based pigments, characteristics and function, 376–379
Micellar electrokinetic capillary chromatography (MECC), condom lubricant residue analysis, 93–96
Micrometry techniques, smokeless powder, 258–259
Micromorphology, smokeless powder, 247–257
Microscopic equipment:
cathodoluminescence, 149
fabric dye analysis, 214
Microspectrophotometry:
fiber color analysis, 198–199
multivariate statistical analysis, 334–336
optically variable pigments, 389–390
Mineral sources:
luminescence, 156–164
accessory minerals, 163–164
calcium carbonate group, 156–158
feldspar group, 159–160
quartz, 160–163
multivariate statistical analysis, 364–366
MK4 First Defense pepper spray, detection and analysis, 130–138
Molecular weights (MWs), laser desorption mass spectrometry, 60–62
Monazite, cathodoluminescence, 163
Monoaxially oriented polypropylene (MOPP), polypropylene packaging tape, 310–313
Morphine, Direct Analysis in Real Time (DART) mass spectrometry, 178–179
Morphology characteristics:
of glitter, 4, 12–13
smokeless powder, 246–247
micrometry techniques, 258–259
Multivariate analysis of variance (MANOVA), separation, classification, and outlier detection, 355–359
Multivariate statistical analysis, chemical characteristics:
accelerants, 359–360
data patterns, 333–336
document examination and currency analysis, 360–362
drug analysis, 362
experimental design and preprocessing, 336–342
fibers, 362–364
glass, 364
group separation, classification accuracy, and outlier detection, 354–359
linear discriminant analysis, 348–354
principal component analysis visualization, 342–348
trace minerals, 364–366
Muzzle-to-target distance, smokeless powder identification and, 245–246

Nanotechnology, surface-modified fibers, 224
Near-infrared fluorescent (NIRF) dyes, latent trace analysis, fingerprints, 126–130
Near-infrared (NIR) dyes, latent trace evidence:
fingerprints detection, 125–130
pepper spray detection, 130–138
Negative ion spectrum, ink analysis, 69
Neutron activation analysis, mineral trace evidence, 364–366
Night vision equipment, latent trace analysis, fingerprints, 126–130
Nikon D1X camera, pepper spray detection, 133–138
Nikon microscopes, cathodoluminescence, 151–152
Nitroaromatic explosives, Direct Analysis in Real Time (DART) mass spectrometry, 186–188
Nitrocellulose, smokeless powder, 243–245
Nitrogen isotope ratios:
drugs of abuse, 408–411
human bone, hair, and teeth, 413–414
Nitroglycerin (NG):
Direct Analysis in Real Time (DART) mass spectrometry, 187–188
smokeless powder history, 245
Nitrosamines, condom trace evidence, 86
forensic protocols, 101
Noise-free values, multivariate statistical analysis, 338–342
Nonoxynol-9, condom trace evidence:
Direct Analysis in Real Time (DART) mass spectrometry, 182–184
forensics applications, 105
spermicide residue analysis, 95–96
Nonparametric sampling, multivariate statistical analysis, 357–359
Normalization:
multivariate statistical analysis, 338–342
principal component analysis, 346–348
Norma 203 smokeless powder, 251–252
Numerical aperture:
cathodoluminescence microscopy, 149
optically variable pigments, 390–391
interference measurements, 394
Nylon windings, electrospray ionization-mass spectrometry analysis, 207–208

Ocean Optics HR2000,
cathodoluminescence, 152
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), Direct Analysis in Real Time (DART) mass spectrometry, 187–188
Oleoresin capiscum (OC), pepper spray detection, 130–138
Oligonucleotide analysis, laser desorption mass spectrometry, 75–76
Opaque pigments, geometric measurements, 390–391
Opiate alkaloids, Direct Analysis in Real Time (DART) mass spectrometry, 178–179
Optically variable pigments (OPVs):  
- additive color theory, 383–385  
- basic principles, 375–376  
- blending protocols, 388  
- color blending, 382–383  
- color gamut creation, 386–387  
- color measurement, 379–382  
- form, characteristics, and function, 376–379  
- future research issues, 395–396  
- geometric measurement, 390–391  
- graphical methods, 385–386  
- magnification switching, 391–392  
- measurement uncertainty, 392–393  
- microspectrophotometry, 389–390  
- sample preparation and measurement, 393–394  
- sample size, 392  
- spectral profiling, 394–395  
- statistical analysis, 395  
- weighted color blending, 387  

Oriented film materials, polypropylene packaging tape, 310–313  
Outlier detection, multivariate statistical analysis, 354–359  
Oxygen isotope ratios, animal and human products, 411–414  

Packaging characteristics, condom trace evidence, case studies, 106–111  
Paint, cathodoluminescence, 170  
Parallel cut patterns, glass cut analysis, 286  
Particle beam techniques, fabric color analysis, 211–214  
Particle characterization:  
- automotive airbag forensics, 36–39  
- glitter, 9  
- size and shape, 13  
- \(p\)-dimensional patterns:  
  - multivariate statistical analysis, 337–342  
  - principal component analysis, 346–348  
Peak broadening, cathodoluminescence and, 145–147  
Peak wavelength, optically variable pigments, 378–379  
Pearl luster pigments, characteristics and functions, 376–379  

Peltier cooling, cathodoluminescence cameras, 150  
Pen inks:  
- analyte target molecules, 63–64  
- laser desorption mass spectrometry, 64–74  
2,4,6-N-tetranitro-N-methylaniline (tetryl), Pentaerythritol tetranitrate (PETN), Direct Analysis in Real Time (DART) mass spectrometry, 187–188  
Pepper spray:  
- Direct Analysis in Real Time (DART) mass spectrometry, 184–185  
- latent invisible trace evidence, 130–138  
- chemical derivatization, 134–138  
- near-infrared dyes, 131–133  
Perception principles, color characterization, glitter traces, 5–6, 11–12  
Perforation characteristics, tubular smokeless powders, 249–250  
Permethrin-treated fabrics, gas chromatography/mass spectrometry analysis, 232–234  
Phlegmatization, smokeless powder history, 244–245  
Phosphorescence, defined, 143  
Photoluminescence, defined, 143  
Photomultiplier tube (PMT), cathodoluminescence, 150  
Photosynthetic pathways, stable isotope ratio analysis, 406–408  
Phthalates, pressure-sensitive tapes:  
- backing materials, 297  
- electrical tape, 307–309  
Pigments:  
- ink analysis, 72–74  
- optically variable pigments, color determination:  
  - additive color theory, 383–385  
  - basic principles, 375–376  
  - blending protocols, 388  
  - color blending, 382–383  
  - color gamut creation, 386–387  
  - color measurement, 379–382  
  - form, characteristics, and function, 376–379  
  - future research issues, 395–396
INDEX

geometric measurement, 390–391
graphical methods, 385–386
magnification switching, 391–392
measurement uncertainty, 392–393
microspectrophotometry, 389–390
sample preparation and measurement, 393–394
sample size, 392
spectral profiling, 394–395
statistical analysis, 395
weighted color blending, 387
Pipe bombs, smokeless powders for, 241–242
P2i plasma process, surface-modified fibers, scanning electron microscopy/energy dispersive spectroscopy, 225–228
Plastics:
  Direct Analysis in Real Time (DART) mass spectrometry, 191–192
  pressure-sensitive tapes:
    backing materials, 297
    pyrolysis gas chromatography/mass spectrometry, 326
Polarized cathodoluminescence microscopy, 149
Polarized light microscopy (PLM):
  automotive airbag forensics, 39–54
  pressure-sensitive tapes:
    component identification, 325–326
    duct tape, 306–307
    sampling protocols, 317
    strapping/filament tape, 314–315
    surface-modified fibers, 223
Polyanionic dyes, laser desorption mass spectrometry, 75–76
Polydimethylsiloxane (PDMS):
  condom lubricant residue analysis, case studies, 106–111
  condom trace evidence, 87
  lubricant coating forensics, 104–105
  residue analysis, 92–96
Polyethylene, rough condom powdering, 86
  forensic analysis, 102–103
Polyethylene terephthalate (PET), glitter from, characterization of, 18–24
Polymers:
  elevated-temperature Direct Analysis in Real Time (DART) mass spectrometry, 190–191
  pressure-sensitive tapes:
    adhesive formulas, 297–299
    backing materials, 297–298
    duct tape reinforcement, 303–307
    Fourier transform infrared analysis, 320–324
Poly(methyl methacrylate) (PMMA),
  glitter from, 20–24
Polypropylene packaging tape, forensic analysis, 309–313
Poly(vinyl chloride) (PVC), pressure-sensitive tapes:
  backing materials, 297
  electrical tape, 307–309
Pooled standard deviation, multivariate statistical analysis, 354–359
Positive ion spectrum, ink analysis, 64–69
Postburn powder characterization, smokeless powder identification, 246
Post-it® notes, glass fragment analysis, 280
Potassium Bromide, smokeless powder characterization, Transmission micro-Fourier transform infrared spectroscopy, 260–261
Poudre B, smokeless powder history, 245
Powder particles:
  condom trace evidence:
    forensic protocols, 101–104
    materials characteristics, 86–87
    residue analysis, 88–91
  smokeless powders:
    ATR-FTIR spectroscopy, 261–262
    basic properties and classification, 241–242
    brand determination, 242–243, 246–257
    ball-shaped powders, 248–249
    disc shaped powders, 253–256
    flattened ball powders, 256–257
    lamella shaped powders, 258
    tubular powders, 249–253
    color, 257–258
Fourier Transform infrared spectroscopy, 260–262
gas chromatograph/mass spectrometry, 262–265
historical background, 243–245
identification, 242, 245–246
kernel/dot configuration, 258
liquid chromatography, 265–266
luster, 258
mass, 259–260
micrometry, 258–259
micromorphology, 247–257
morphology, 246–247
transmission micro-FTIR, 260–261
Preservatives, condom trace evidence, 86
Pressure sensitive tape:
adhesive formulas, 297–299
backing, reinforcement and adhesive separation, 319
backing materials, 296–297
construction, 293–296
duct tape, 299–307
electrical tape, 307–309
 elemental analysis, 320, 324–325
end matching techniques, 318–319
forensic analysis of, 291–292
case studies, 327–329
Fourier transform infrared analysis, 320–324
initial examination protocols, 316–317
interdepartmental protocols, 317
manufacturing source identification, 326–327
masking tape, 315–316
physical characterization, 319
polarized light microscopy, 325–326
polypropylene packaging tape, 309–313
machine edge offset, 313
orientation marks, 311
oriented films, 310
polarized light microscopy analysis, 310
thickness, 312
product variability, 292–293
pyrolysis gas chromatography/mass spectrometry, 326
reinforcement fabrics, 299
strapping/filament tapes, 313–315
trace evidence recovery and untangling of, 318
Presumptive testing:
latent bloodstains, 117–125
pepper spray detection, 134–138
trace evidence, 116–117
Primary colors, additive color theory, 383–385
Principal component analysis (PCA):
accelerator applications, 359–360
development and application, 336
dimensionality reduction, 342–348
document examination and currency analysis, 360–362
drug analysis, 362
fibers, 362–364
glass analysis, 364
linear discriminant analysis, 349–354
mineral trace evidence, 364–366
Property damage accidents, automotive airbag forensics, 50–54
Protonated molecules, drug/pharmaceutical analysis, Direct Analysis in Real Time (DART) mass spectrometry, 177–180
Protonation detection technique, pepper spray analysis, 131–138
Proton nuclear magnetic resonance, condom lubricant residue analysis, 92–96
Provenance, cathodoluminescence, 166
Pulsed-discharge electron capture detector (PDECD), surface-modified fibers, 238
Pyrolysis gas chromatography/mass spectrometry (PGC/MS):
condom lubricant residue analysis, 92–96
document examination and currency analysis, 360–362
pressure-sensitive tapes, 326
surface-modified fiber analysis, 234–238
Pythagorean theorem, multivariate statistical analysis, 355–359
Quartz, cathodoluminescence, 160–163
Quencher atoms, cathodoluminescence, 146–147
Questioned sample (Q):
  glitter characterization and, 10–24
color analysis, 11–12
  particle size, 13
  surface-modified fibers, 222–224
  pyrolysis gas chromatography/mass spectrometry, 234–238

Raman microspectroscopy:
  glitter characterization, 19–22
  multivariate statistical analysis, 339–342
  surface-modified fibers, 224

Rare earth elements (REEs):
  cathodoluminescence, 146–147
  accessory minerals, 163–164
  calcium carbonates, 158
  feldspar group, 160
  stable isotope ratios, 413–414

Rayon fibers, duct tape reinforcement, 303–307

Reflectance infrared spectroscopy:
  ink analysis, 57–58
  optically variable pigments, 376–379

Reflecting pigments, geometric measurements, 390–391

Reflection measurements, optically variable pigments, 389

Refractive index (RI):
  glass analysis, 364
  pressure-sensitive tapes, 326

Reinforcement materials, pressure-sensitive tapes, 296
  duct tapes, 299–307

Release coats, pressure-sensitive tape, 293–294

Retention properties, glitter, 3

Rhodamine dyes:
  ink analysis, 69–71
  latent bloodstain analysis, 121–125

Robbery cases, glass cuts as evidence in, 271–274

Rubber materials, pressure-sensitive tapes:
  adhesive formulas, 297–299
  duct tape, 300–307

Rutile, cathodoluminescence, 168–171

Sample alteration, cathodoluminescence, 155

Sample-electron interactions, cathodoluminescence, 141–142

Sample preparation and preservation:
  cathodoluminescence, 152–153
  multivariate statistical analysis, 336–342
  randomization and classification, 357–359
  optically variable pigment measurements, 393–394

Sample size, optically variable pigments, 392

Savitzky-Golay algorithm, multivariate statistical analysis, 338–342

Scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS):
  pressure-sensitive tapes, 324–325
  surface-modified fibers, 225–231
  low-voltage techniques, 230–231
  3M protective finish, 229–230
  P2i-treated samples, 225–228

Scanning electron microscopy (SEM):
  cathodoluminescence, 149
  instrumentation, 150
  quartz, 163
  document examination and currency analysis, 360–362
  glitter analysis, 22–23
  glitter characterization, criminal case studies of, 25–31
  optically variable pigments, 376–379, 395

Scanning electron microscopy/wavelength dispersive X-ray spectroscopy (SEM-WDS), pressure-sensitive tapes, 324–325

Scissors cuts, glass cuts compared with, tearing patterns in fabric, 277–279

Screening techniques, cathodoluminescence, 165

Scrim patterns, duct tapes, 300–307
Selected ion monitoring (SIM), surface-modified fibers, pyrolysis gas chromatography/mass spectrometry, 235–238
Self-defense sprays, Direct Analysis in Real Time (DART) mass spectrometry, 184–185
Sensitizer atoms, cathodoluminescence, 146–147
Separation techniques:
glitter traces, 8–9
multivariate statistical analysis, 354–359
pressure-sensitive tapes, 318–319
Sexual assault crimes, glitter as evidence in, 26–31
Shape properties, of glitter, 3, 13
Shard glass, analysis of, 281–282
“Shimmer” materials, 2
Short tube smokeless powders, 252–253
Silica particles:
cathodoluminescence, quartz, 160–163
condom trace evidence, 86–87
forensic analysis, 103–104
Silicon compounds,
cathodoluminescence, feldspar group, 159–160
Silicone, condom lubricants:
materials characterization, 86
residue analysis, 92–96
Singe patterns, automotive airbags, 37–54
Singular value decomposition, principal component analysis, 343–348
Size properties, of glitter, 3, 13
Slag, cathodoluminescence, 168–169
Slash cut patterns, glass cuts and, 279–280
Smiths Detection Application Brief, glitter thickness characterization, 14–15
Smokeless powders:
ATR-FTIR spectroscopy, 261–262
basic properties and classification, 241–242
brand determination, 242–243, 246–257
ball-shaped powders, 248–249
disc shaped powders, 253–256
flattened ball powders, 256–257
lamella shaped powders, 258
tubular powders, 249–253
color, 257–258
Fourier Transform infrared spectroscopy, 260–262
gas chromatograph/mass spectrometry, 262–265
historical background, 243–245
identification, 242, 245–246
kernel/dot configuration, 258
liquid chromatography, 265–266
luster, 258
mass, 259–260
micrometry, 258–259
micromorphology, 247–257
morphology, 246–247
transmission micro-FTIR, 260–261
Smoothing, multivariate statistical analysis, 338–342
Sodium azide gas, automotive airbags, 34–35, 37–39
Sodium hydroxide, automotive airbags, 35
Soft independent modeling of class analogy (SIMCA):
amphetamines, 362
document examination and currency analysis, 360–362
multivariate statistical analysis, 356–359
Soil and sand characterization, cathodoluminescence, 167
Solid propellants, automotive airbags, 34–35
Source locations, stable isotope ratio analysis, 404–405
Specific gravity, of glitter, 4, 13–14
Spectral data collection:
cathodoluminescence, 153–154
latent trace analysis, fingerprints, 126–130
multivariate statistical analysis, 334–336
optically variable pigments, 394–395
Spectrometry equipment, cathodoluminescence, 150
Spermicides, condom trace evidence:  
forensics applications, 105  
materials characterization, 87  
residue analysis, 95–96  
Spherical® powders, smokeless powder characterization, 249  
Spinel, cathodoluminescence, 163–164  
glass materials, 169  
Sports doping, stable isotope ratio analysis, 410–411  
Stable isotope ratio analysis:  
abundance variations, 401–402  
basic principles, 399–400  
delta notation, 401  
forensics applications, 404–416  
bones, hair, and teeth, 413–414  
doping and drug abuse cases, 408–411  
food products, authenticity, and adulteration, 406–408  
human/animal products and sourcing, 411–413  
manufactured items, 414–416  
instrumentation, 402–403  
isotope distribution and properties, 400–401  
Standard Mean Ocean Water (SMOW), stable isotope ratio analysis, 401  
Starch particles:  
avtomotive airbag forensics, 36–37, 41–54  
smokeless powder history, 244  
Statistical testing. See also Multivariate statistical analysis  
optically variable pigments, 395  
Stereo light microscope (SLM):  
smokeless powder characterization, 246–247  
smokless powder identification, 242  
Strapping/filament tapes, forensic analysis, 313–315  
Strontium, stable isotope ratios, 413–414  
Student’s t-test:  
multivariate statistical analysis, 354–359  
optically variable pigments, 395  
Sulfur isotopes, ink analysis, 72–74  
Surface anesthetics, condom trace evidence, 87  
Surface properties:  
cathodoluminescence, calcium carbonate, 158  
drug/pharmaceutical analysis, Direct Analysis in Real Time (DART) mass spectrometry, 179–180  
fiber analysis:  
distinguishing tests, 225  
gas chromatography/mass spectrometry, 231–234  
preliminary examinations, 222–224  
pyrolysis gas chromatography/mass spectrometry, 234–238  
research background, 221–222  
scanning electron microscopy/energy dispersive spectroscopy, 225–231  
structural properties, 222  
latent trace analysis, bloodstains, 122–125  
Tackifiers, pressure-sensitive tapes, 297–299  
Talcum powder particles:  
avtomotive airbag forensics, 37–39  
cathodoluminescence, 168–171  
condom trace evidence, 86  
forensic analysis, 103  
Tandem mass spectrometry (MS/MS), fabric dye analysis, 202–203  
direct infusion protocol, 214–216  
electrospray ionization and, 204–207  
structural elucidation, 208–210  
thermospray techniques and, 212–214  
Tape products. See Pressure sensitive tape  
Teeth, stable isotope ratios, 413–414  
Tetrahydrofuran (THF), electrical tape, 307–309  
Thermospray interfaces, fabric color analysis, 211–214  
Thickness properties:  
of glitter, 4, 14–15  
polypropylene packaging tape, 312–313
Thin film interference, optically variable pigments, 378–379

Thin-layer chromatography (TLC):
  fiber color analysis, 198–199
  ink analysis, 69

3M protective finish, surface-modified fibers, scanning electron microscopy/energy dispersive spectroscopy, 229–230

Time-of-flight (ToF) mass spectrometry, ink analysis, 60–62

Tin compounds, cathodoluminescence, 169

Titanium dioxide, optically variable pigments, 376–379

Total ion current (TIC) analysis:
  BUZZ OFF™ fabrics, 232–234
  fabric dyes, 202–203
  trace quantity extraction, 213–214
  pepper spray detection, 136–138

Total reflection X-ray fluorescence spectrometry (TXRF), cathodoluminescence, 169

Traffic violations, automotive airbag forensics, 50–54

Transfer properties, glitter, 3

Translucent pigments, geometric measurements, 390–391

Transmission measurements:
  cathodoluminescence spectral collection, 153–154
  optically variable pigments, 389

Transmission micro-Fourier transform infrared spectroscopy, smokeless powder characterization, 260–261

Transparent/semitransparent pigment blending:
  geometric measurements, 390–391
  optically variable pigments, 388

Transport medium, glitter, 8

Trapezoid kernels, smokeless powder characterization, 248

Triacetone triperoxide (TATP):
  Direct Analysis in Real Time (DART) mass spectrometry, explosive materials, 186–188
  fingerprint analysis, 181

Triethylamine (TEA), fabric dye analysis, mass spectrometry analysis, 214

2,4,6-Trinitrotoluene (TNT), Direct Analysis in Real Time (DART) mass spectrometry:
  explosives, 186–188
  fingerprint analysis, 180–181

Tristimulus values:
  additive color theory, 384–385
  optically variable pigments, color matching functions, 380–382

Tubular powders, smokeless powder characterization, 249–253

Ultraviolet-visible spectrum:
  fiber color analysis, 199–203
  ink analysis, 57–58
  cationic dyes, 67–69
  latent trace evidence, pepper spray analysis, 130–138
  linear discriminant analysis, 351–354
  multivariate statistical analysis, 337–342
  dimensionality reduction, 342–348
  fibers, 362–364
  pepper spray detection, 133–138
  UMPLFL lens, glitter characterization, 20–22

Univariate data analysis, group separation, classification accuracy, and outlier detection, 354–359

Urine, Direct Analysis in Real Time (DART) mass spectrometry, 181–182

Variable pressure (VP) scanning electron microscopy, cathodoluminescence, 165

Vehicle characteristics. See also Automotive airbags glitter traces, 8

Video microscopy, glitter particle size and, 13

Vilsmeier-Haack reagent, latent trace analysis, fingerprints, 129–130
Visible spectrum, optically variable pigments, 379–382
Visualization technology:
   latent trace analysis:
      chemical characterization, 116–117
      fingerprints, 126–130
      linear discriminant analysis, 348–354
      masking tape forensics, 316
      pepper spray detection, 134–138
Vulcanization process, condom trace evidence, 86
VX agent ([O-ethyl S-(2-diisopropylaminoethyl)
methylphosphonothioate]), Direct Analysis in Real Time (DART) mass spectrometry, 189–190
Wavelength accuracy, cathodoluminescence spectral collection, 153–154
Wearing and worn damage, glass cut analysis, 286–287
Weight properties, optically variable pigment blending, 387
Winding samples:
   fiber color analysis, 200–203
   negative ion ESI-MS analysis, nylon winding, 207–208
Xlyoidine, smokeless powder history, 244
X-ray fluorescence (XRF):
   document examination and currency analysis, 360–362
   pressure-sensitive tapes, 324–325
X-ray powder diffraction (XRD), pressure-sensitive tapes, 324–325
ZAF-related corrections, cathodoluminescence, 147
Zincite, cathodoluminescence, 168–171
Zinc oxide, pressure-sensitive tapes, duct tapes, 300–307
Zircon, cathodoluminescence, 163
Zoning, cathodoluminescence, calcium carbonates, 158