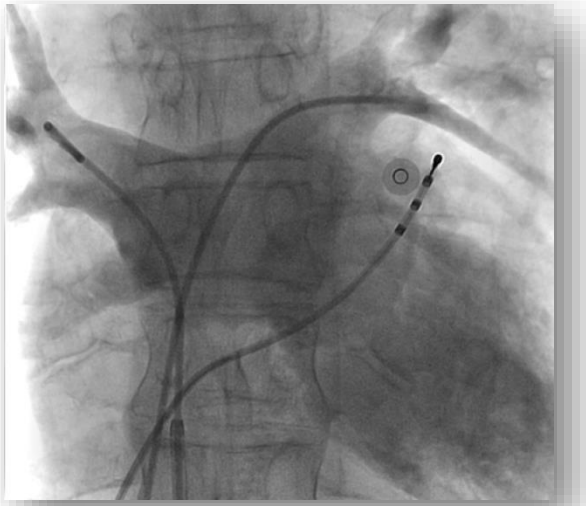
# Radiopaque Compounds

## for minimally invasive medical devices

# Purpose of Radiopaque Compounds



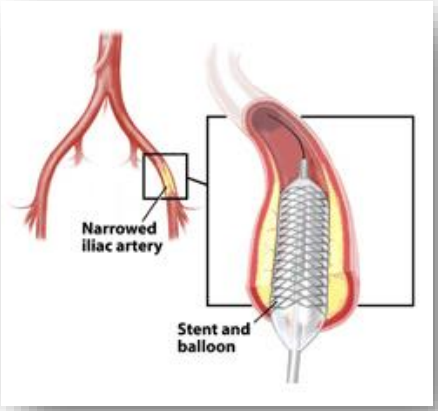
Polymers: *inherently transparent to x-ray*

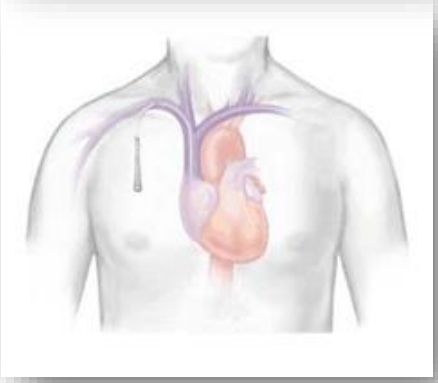
Radiopaque fillers: *visible under x-ray*

Radiopaque compounds: *visible under x-ray imaging or fluoroscopy*

**Surgeon can follow device through body**

# Applications



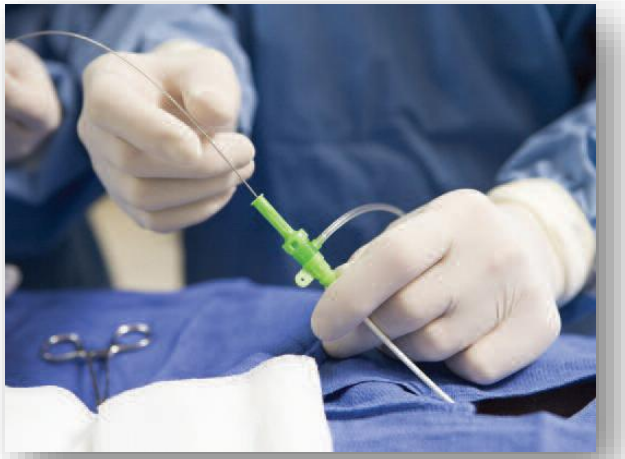
- PTCA Catheters
- Central Venous Catheters
- Foley Catheters
- Naso Gastric Feeding Tubes
- Pacemaker Lead Placement
- Neurovascular Catheters
- Diagnostic Cardiovascular Catheters

# Polymers used for Devices

| Category | Class | Examples |
|---|---|---|
| Specialty | Polyolefins | LDPE, HDPE, LLDPE, PP |
| | Styrenics | PS, SAN, ABS, HIPS |
| | Vinyls | PVC, EVA |
| Engineering | Polyamides | Nylon 6, 6/6, 6/10, 6/12, 11, 12, Amorphous |
| | Polyesters | PET, PBT, PETG |
| | Acetals | Copolymer, Homopolymer |
| | Thermoplastic Elastomers | PU, PEBA, COPE |
| | Polycarbonate | |
| Performance | High Temperature | PEEK, PES, PPS, PSU, LCP |
| | Fluoropolymers | FEP, PVDF, ETFE |

# Common Radiopaque Fillers

Barium sulfate
Bismuth subcarbonate
Bismuth trioxide
Bismuth oxychloride
Tungsten



# Selecting Radiopaque Fillers

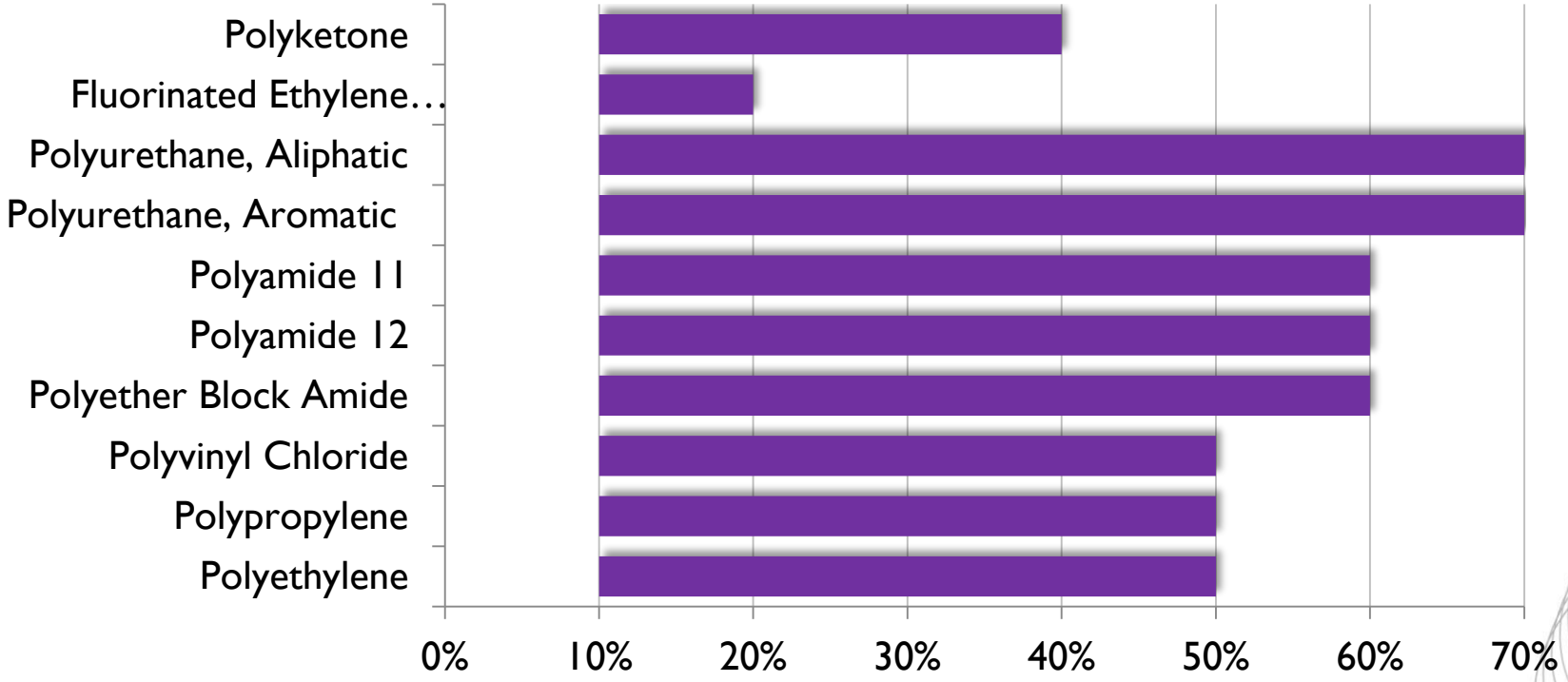
Base resin
Tubing wall thickness
Surface smoothness needed
Color
Physical properties needed in end device
Where device will be used in the body
Sterilization technique
Economics

# Barium Sulfate ($BaSO_4$)

First widely used in medical formulations
Relatively inexpensive white powder
Very process stable
Must be pre-dried
Loadings of 40-60% depending on polymer
Require high loading for equivalent radiopacity
White: easy to color but poor tinting strength

# Barium Sulfate

## Typical Loading Levels



# Bismuth Subcarbonate ($Bi_2O_2CO_3$)

White: strong pigment & difficult to color match

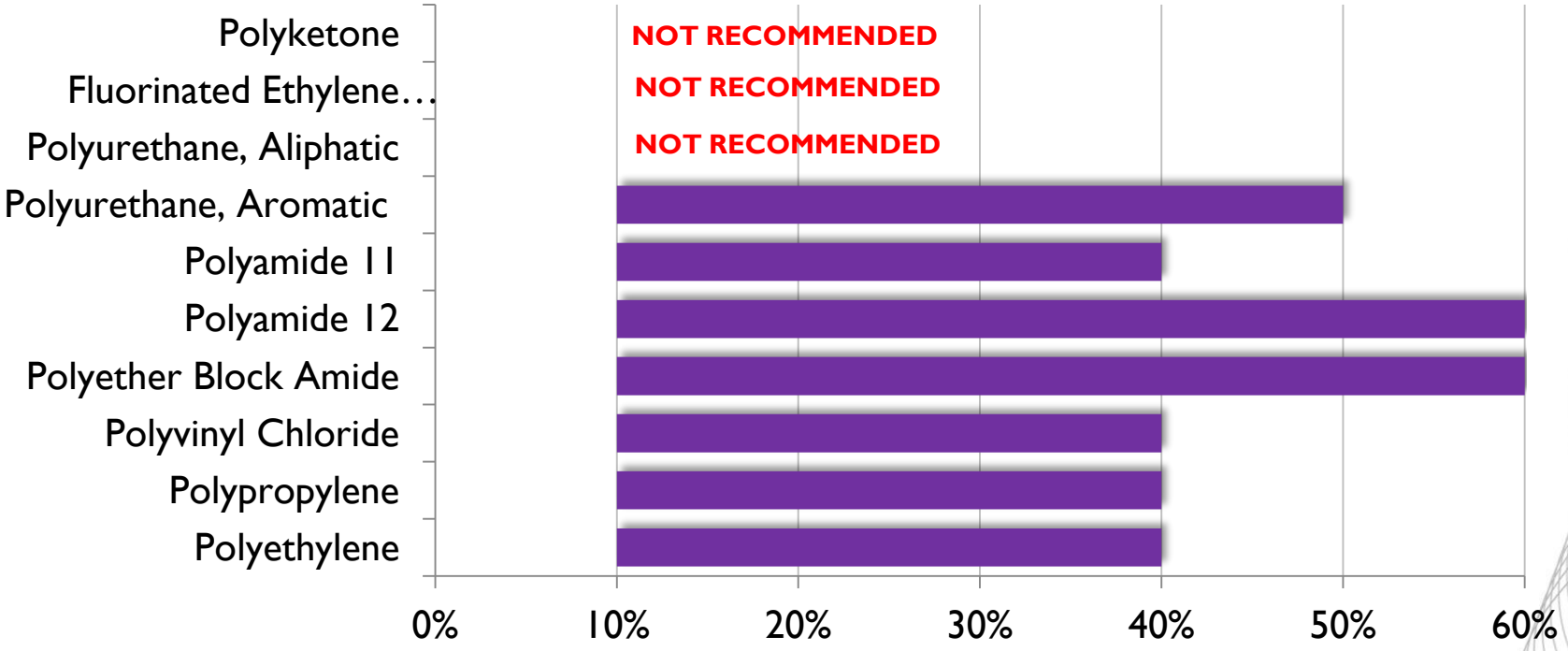
Loadings of 30-50% by weight possible

Unstable at temperatures above 400°F (yellows)

Not compatible with some TPU's

# Bismuth Subcarbonate

## Typical Loading Levels



# Bismuth Trioxide ($Bi_2O_3$)

Yellow color

Turns brown at high processing temperature

Can be loaded up to 60% by weight

Can get gritty surfaces

Compatible with most resins

# Bismuth Trioxide
## Typical Loading Levels

# Bismuth Oxychloride (BiOCl)

White color

More temperature stable than bismuth subcarbonate

Compatible with a wide range of resins

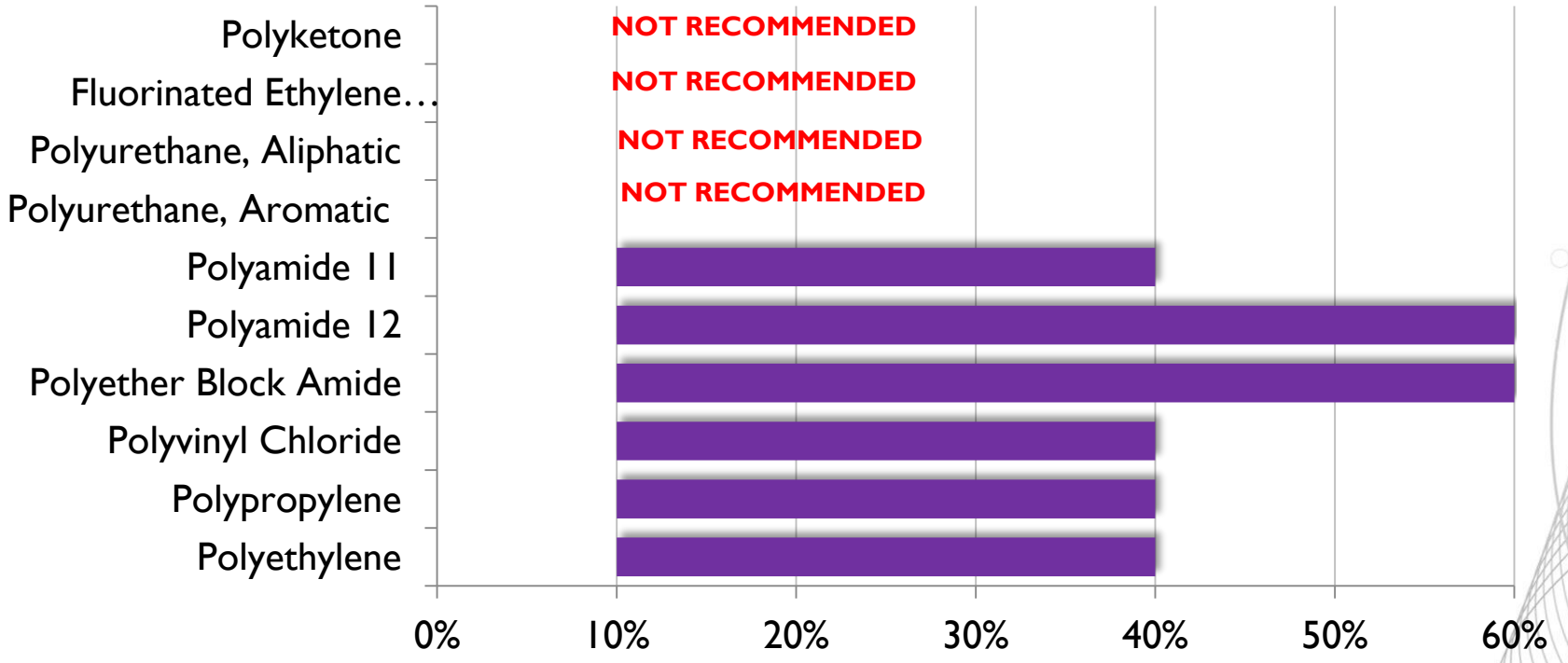
"Platelet-like" particles provide smooth shiny surface

Susceptible to UV degradation *(requires UV stabilizer)*

Difficult to color *(can produce a "pearlescent" finish)*

# Bismuth Oxychloride

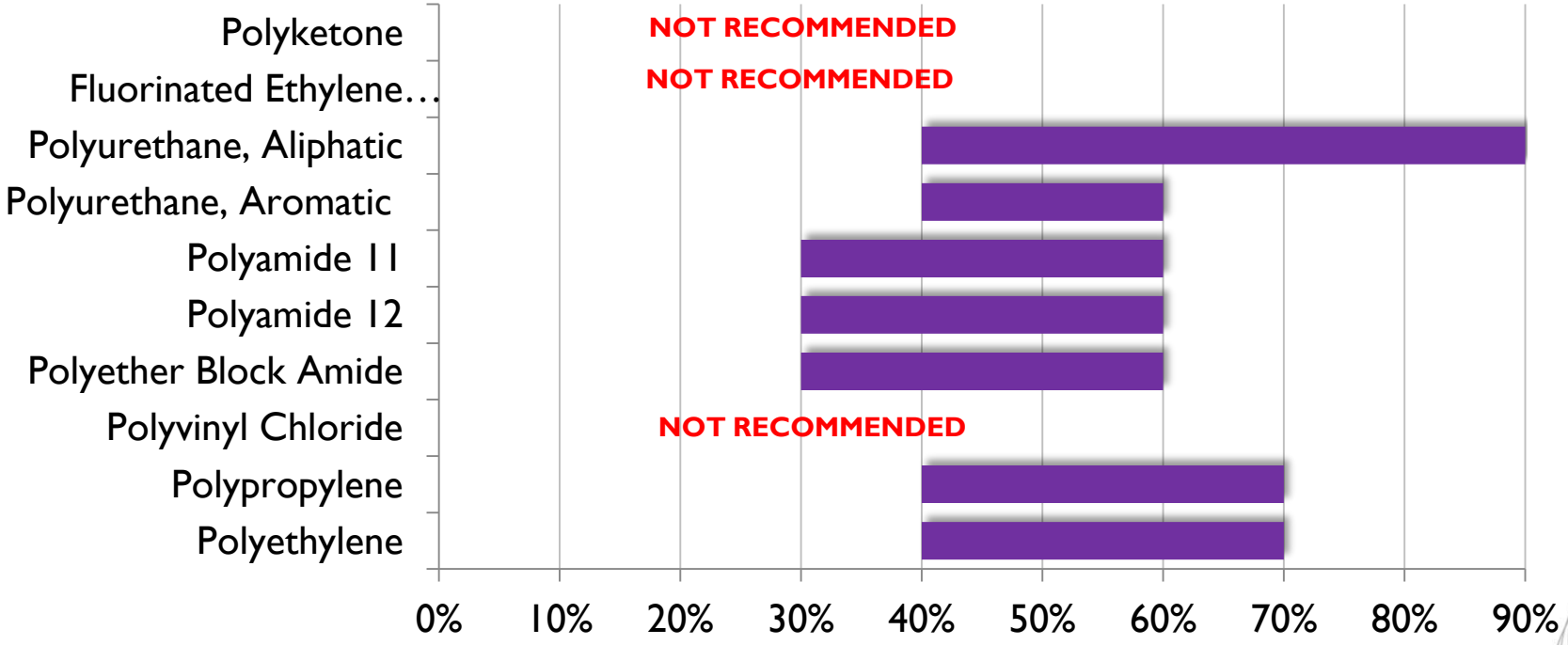
## Typical Loading Levels

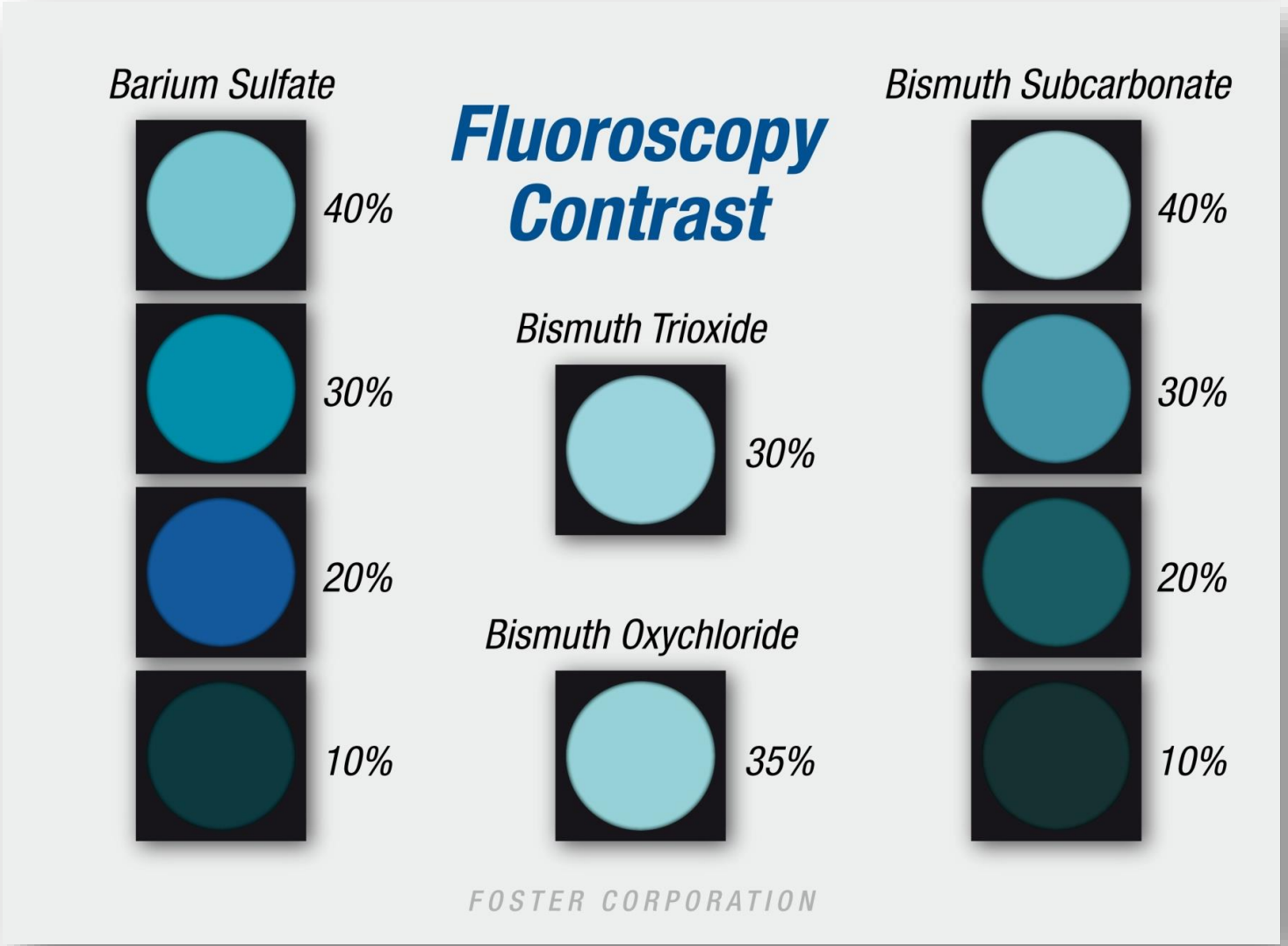


# Tungsten (W)

Very heavy, dark metal powder *(hard to color)*
Compatible with virtually any resin
Loading up to 90% by weight possible
Can show matte finish in high loadings
Very abrasive *(high wear to process equipment)*
Filler of choice in very thin walled devices
Oxidation in the presence of oxygen and heat
Highly flammable *(pay particular attention to drying techniques)*

# Tungsten
## Typical Loading Levels




Barium Sulfate
40%
30%
20%
10%
Fluoroscopy Contrast
Bismuth Trioxide
30%
Bismuth Oxychloride
35%
Bismuth Subcarbonate
40%
30%
20%
10%
FOSTER CORPORATION

# Radiopaque Filler Summary

| Radiopaque Filler | Price | Specific Gravity ($gm/cm^3$) | Heat Stability ($^oF$) | Particle Size ($\mu m$) | Characteristics |
|---|---|---|---|---|---|
| **Barium Sulfate** | $ | 4.4 | 700 | 0.5-2 | White powder, medium bulk density, compacts, semi-free flowing with assist |
| **Bismuth Subcarbonate** | $$ | 8 | 400-450 | 1-2 | Pale white powder, free-flowing, dusty, low to medium bulk density |
| **Bismuth Oxychloride** | $$ | 8.9 | 400* | 1-2 | Yellow powder, high bulk density, free-flowing, *turns brown at approx. 400°F |
| **Bismuth Trioxide** | $$$ | 7.8 | 500 | 2-12 | White to light gray powder, very dusty, low to medium bulk density, semi free-flowing |
| **Tungsten** | $$$$ | 19.3 | ** | 1-2 | Very heavy, steel color powder, abrasive, ** unstable in oxygen, very stable once dispersed in plastic |