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Radio-visibility of Medical Grade Polymers During X-ray Imaging

The radio-visibility of a given polymer depends on on its elemental composition. Heavier elements are more capable of attenuating X-rays than lighter elements. Medical grade polymers manufactured by Solvay Specialty Polymers for Healthcare applications are mostly composed of lighter elements, such as hydrogen (Z=1) and carbon (Z=6). Most polymers in their natural form are barely visible (radio-transparent), while most metals are highly visible (radio-opaque). However, with the addition of reinforcements and/or additives, plastics may also exhibit radio-opaque behavior.

Effect of Reinforcements on Radio-visibility

The most common reinforcements utilized for medical devices are carbon fibers and glass fibers. Since most polymers are composed largely of carbon, the use of carbon fibers has little impact on radio-visibility. However, glass fibers are composed of a wide range of elements, with the most common ones being aluminum (Z=13), silicone (Z=14), and calcium (Z=20). Typical glass fiber reinforcement between 10 % to 60 % can significantly increase the radio-visibility of a polymer.

Effect of Coloring Pigments on Radio-visibility

Coloring pigments are the most commonly used additives for medical devices. Most polymers are capable of achieving a wide range of colors with a pigment loading ≤ 5 %. For example, a typical pigment used to make a polymer white is titanium dioxide (TiO_2). Even at 5 %, the presence of oxygen (Z=8) and titanium (Z=22) can significantly increase the radio-opacity of a polymer.

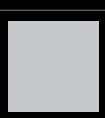
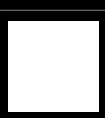
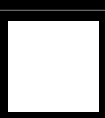
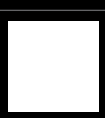
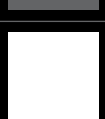
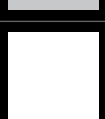
Testing Radio-visibility

ASTM flex bars with a nominal thickness of 3.2 mm (0.126 in.) were scanned using a Hewlett Packard Faxitron X-ray System model #43804-5-7N. To observe the effect of varying thickness, the samples were placed in stacks of one to four, resulting in thicknesses of 3.2 to 12.8 mm (0.126 to .504 in.). A 3.2-mm (0.126-in.) titanium sample was used as a metal reference.

The scan results were desaturated to grayscale using luminosity as a reference. The grayscale color range was extended to pure black and pure white. Finally, the colors of the grayscale image were inverted to better represent commonly depicted x-ray images (Figure 1). Therefore, black represents radio-transparency and white represents radio-opacity. Results for select grades of Solvay's medical grade polymers that carry an ISO 10993 rating are presented in Table 1. The reinforcements and/or additives present are noted below each material.

Figure 1: Representative x-ray image

Table 1: Effect of varying thicknesses on radio-visibilty

Material	Thicknesses				
	3.2 mm	6.4 mm	9.6 mm	12.8 mm	3.2 mm TiO_2
Ixef® PARA					
GS 1022 WH01 (Opaque / white, 50 % glass fibers)					
Udel® PSU					
P-1700 NT11 (Natural)					
P-1710 NT15 (Pigment)					
Radel® PPSU					
R-5000 NT (Natural)					
R-5100 NT15 (Pigment)					
AvaSpire® PAEK					
AV-651 NT (Natural)					
AV-651 GF30 BG20 (Pigment & 30 % glass fibers)					
AV-651 CF30 (30 % Carbon fibers)					
KetaSpire® PEEK					
KT-880 NT (Natural)					
KT-880 GF30 BG20 (Pigment & 30 % glass fibers)					
KT-880 CF30 (30 % Carbon fibers)					

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