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Optimizing Curing of Lubricious Coating on Implantable Medical Devices Using UVA and UVC

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OVERVIEW

Ultraviolet (UV) curing is commonly used to cure lubricious coatings on implantable medical devices such as catheters and guidewires, examples include hydrophilic and hydrogel coatings. Many applications rely primarily on UVA energy, but studies have shown that introducing low levels of UVC energy following the initial cure can significantly improve coating performance and process robustness.

The combination of UVA and UVC

UVA wavelengths (typically 320–405 nm) are commonly used to cure medical coatings, as they provide deep penetration through transparent and semi-transparent materials and efficiently activate a wide spectrum of photoinitiators responsible for initiating polymerization. This deep penetration causes uniform crosslinking throughout the coating, which is essential for achieving consistent mechanical integrity.

In contrast, UVC (typically 200–280 nm) does not penetrate deep into the coating but is strongly absorbed near the coating surface due to the shorter wavelengths of UVC relative to UVA.

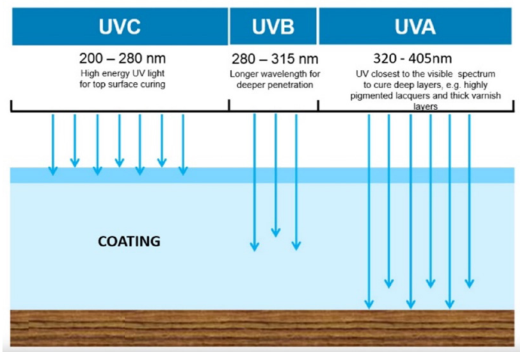

Figure 1: UVC Penetration vs UVB and UVA

When used in conjunction with UVA, UVC provides several important benefits.

1. UVC enhances surface cure by minimizing oxygen inhibition. Oxygen present at the coating-air interface can inhibit polymerization, leading to tacky or under-cured surfaces. Because UVC overcomes oxygen inhibition it will promote rapid skin formation. This is valuable for lubricious coatings, where surface integrity directly affects the coefficient of friction.
2. The combination of UVA and UVC improves through-cure uniformity. In a dual-wavelength process, UVA drives deep polymerization while UVC ensures complete conversion at the outermost surface. For implantable devices, this translates to better adhesion, improved wear resistance, and reduced risk of coating delamination during clinical use.
3. UVC can assist in activating legacy photoinitiator molecules. As more applications transition to LED-based UV systems, achieving compatibility with well-established coatings can sometimes be challenging when only a single wavelength is used.

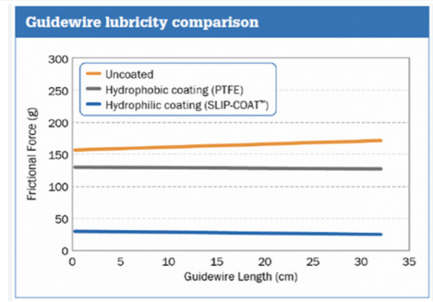

Figure 2: Friction Force Comparison

Line speed and process flexibility also benefit from a UVA/UVC combination. A typical approach uses high-intensity UVA for primary cure followed by a brief low level UVC exposure to enhance the surface cure. This staged curing method can reduce total exposure time while improving coating quality. Optimizing cure profiles and UVA/UVC ratios can significantly improve curing in complex geometries, such as long, small-diameter catheters where shadowing can limit UV exposure.

Another advantage of UVC is improved coating durability. Enhanced total crosslinking, especially at the surface, improves abrasion resistance and reduces the likelihood of particulate shedding, a critical requirement for implantable medical devices.

Successful UVA/UVC implementation requires careful process control. Excessive UVC exposure can result in brittle surfaces, yellowing, or even substrate damage. Achieving optimal performance requires aligning wavelength ratios with photoinitiator chemistry, coating thickness, and line speed.

Conclusion

UVA and UVC energies play distinct yet complementary roles in curing lubricious coatings for implantable medical devices. UVA provides deep, uniform cross-linking, while UVC strengthens surface cure and mitigates oxygen inhibition. When properly balanced, this dual-wavelength approach delivers faster processing, more complete crosslinking, and superior coating durability for minimally invasive medical devices.