Rapid Prototyping Resin Unlocks a New Opportunity for Direct Manufacturing

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Varian, Inc., a leader in Nuclear Magnetic Resonance (NMR) technology, produced the first commercial NMR spectrometer more than 50 years ago. Since then, NMR has become a standard technique for chemical, biological, medical, and physical research. NMR imaging systems are recognized as significant tools for medical diagnostics.

Miniature spatial phantoms. From left to right: Micro-Imaging Gradient Standard, Magnetic Resonance Imaging Gradient Standard, Stereolithography Gradient Standard.

NMR works because atomic nuclei behave like magnets when exposed to an external magnetic field. Under such conditions, the spinning nuclei create small magnetic fields that can be stimulated using specific frequencies of electro-magnetic energy. The result is that radio waves are emitted. Those waves can be measured to create a visual image of both the molecular structure being studied and its environment.

In developing NMR technology, it is essential to anticipate the performance of emerging devices. This is complicated by the fact that imaging systems may feature varying global standards. Therefore, it is usually not practical to use humans to test and verify performance. This challenge is resolved by using a "phantom." Phantoms are objects that do not occur in nature but can be created to replicate a human standard that can be imaged to test the performance of magnetic imaging systems. These phantoms are kept on site to verify system performance through quality assurance protocols.

Recently, Varian [1] was commissioned to develop miniature spatial phantoms for use in testing and calibrating gradient systems in small and micro-bore magnetic resonance imaging systems. For clinical systems, these types of phantoms are most often constructed from machined plastic. For the smaller scale phantoms needed for Micro-Imaging, this is not feasible and we turned to Stereolithography

technology to achieve the needed detail. Portions of the inside of the phantom are removed to create a test pattern, after which the phantom is filled with an aqueous solution. When imaged, the NMR device displays the signal from the water in the water-filled sections of the plastic. It was therefore necessary to create a device that could withstand rigorous use with aqueous substances. To do so, we had to first identify a resin with characteristics encompassing low water absorbency coupled with superior transparency necessary for detecting and removing undesirable air bubbles.

Stereolithography (SL) is a process that permits rapid creation of 3D pieces, utilizing a computer-controlled laser that polymerizes light-sensitive resins. SL is highly precise, and constructs the object in a series of "additive layers." As a technology for prototyping our spatial phantom device, SL was an ideal methodology; however, selection of a resin remained a key priority.

In exploring resin opportunities, we were quickly able to identify several options that seemed to match our requirements. We ultimately selected a SL resin that allegedly simulated the appearance and physical characteristics of polycarbonate. At the surface level, this seemed appropriate, because polycarbonate has low water absorbency and is the plastic of choice for larger phantoms. Moreover, polycarbonates feature high temperature resistance, high impact resistance and clear optical properties. Consequently they are widely used in the medical and chemical industries.

Improper Material Selection Leads to Prototyping Failures

While our first choice did have many attributes similar to polycarbonate, it was not tolerant of aqueous environments. Within one week, the prototyped product we created failed because the part was moisture sensitive. As a result, it expanded and distorted in an aqueous environment. The vendor did say that the resin was sensitive to humidity, but they did not have any water absorbency data available.

Testing SL Resins Demonstrates That Proof is in the Performance

Our unfavorable experience with the initial SL resin caused us to seek input from Protogenic, Inc. (our SL prototype supplier) who suggested several alternatives. This time, however, rather than proceeding to actual prototyping of the device, we established a resin evaluation procedure.

We subjected small tokens made from a number of resins to a long-term soak test in a relevant aqueous solution. We made periodic weight and size measurements of those samples over the course of seven months.

Although testing SL resins was time consuming, we saved time and backtracking by first determining the resin most appropriate to our needs. The resin that prevailed was WaterShed, developed by DSM Somos.

Conclusion

Proper resin evaluation took time initially, but saved time in the end, by leading

Varian to the best material option for rapid, direct manufacture of a medical device component. WaterShed is an optically clear rapid SL prototyping resin developed by DSM Somos to provide ABS-like properties, clarity, and excellent temperature resistance. WaterShed proved, in our application, to produce clear, functional, accurate parts that simulate acrylic in appearance.

Most importantly, WaterShed XC 11122 [2]provided the lowest available water absorption versus alternative resins. We successfully used two grades: WaterShed XC 11122 and XC 11112. Resistance to moisture resulted in excellent dimensional and physical property stability. This facilitated direct, rapid manufacture of the phantoms using the stereolithography process.

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