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Introducing ZEONEX® 360R, Zeon's specialty Cyclo Olefin Polymer optical resin for improved VR performance and Blue Laser applications.

Zeon Corporation is announcing the commercial availability of ZEONEX® 360R, a new grade of Cyclo Olefin Polymer. Specifically designed for VR, Blue Laser applications and Automotive Heads-up Displays (HUDs), this optical resin combines the low birefringence of currently available ZEONEX® K26R, the high environmental stability (light, temperature, humidity) of ZEONEX® 350R and the production capacity of other grades. Manufactured at Zeon's Mizushima plant, ZEONEX® 360R sets a new standard for performance in a cost-effective and high production capacity resin.

Low Water Absorption for Precision Optics

ZEONEX® and ZEONOR® have been widely adopted for optical applications. High transmittance from UV to NIR wavelengths, precision molding of sub-um features and tight dimensional stability result in a polymer with the transparency of glass but the performance of an injection molded resin. ZEONEX® and ZEONOR® are also widely used in Life Sciences applications for drug container systems (syringes and vials) as well as in diagnostic assays (microplates, microfluidics) because of their very high purity and barrier properties. A hallmark of all ZEONEX® and ZEONOR® is their very low water absorption and high

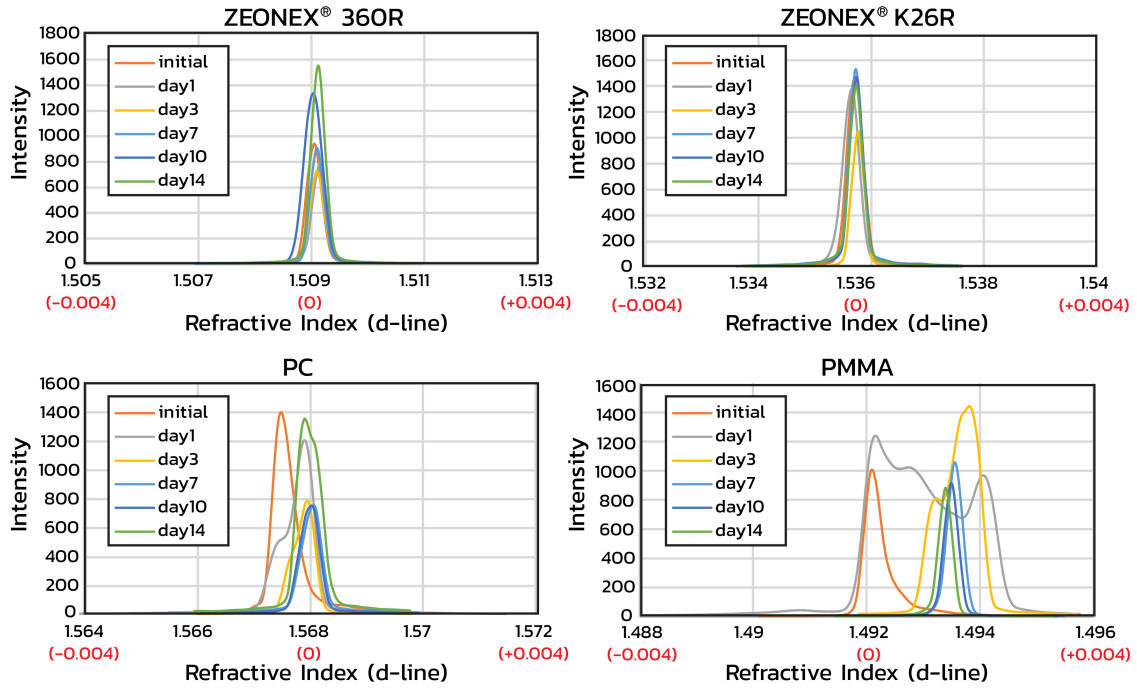

Figure 1. Shift in refractive index of ZEONEX® 360R, ZEONEX® K26R, Polycarbonate (PC) and Polymethyl Methacrylate (PMMA) after storage at 90% RH and 60 °C.

dimensional stability, across all grades, which is critical for high performance optical applications. Materials that are prone to higher rates of water absorbance can experience a shift in dimensions, resulting in a shift in refractive index and other optical properties.

To explore the environmental stability of ZEONEX® 360R, optical performance was tested under high humidity conditions. Its performance was compared to ZEONEX® K26R, traditionally utilized for challenging environmental conditions because of its high resistance to water absorbance. Polycarbonate (PC) and Polymethyl methacrylate (PMMA) were also included in the study because they are commonly used for optical lenses. Molded test pieces were stored at 90% relative humidity and 60 ºC for 14 days, and the shift in refractive index (RI) was measured using a precision refractometer. As shown in Figure 1 both ZEONEX® K26R and ZEONEX® 360R showed little to no impact with a shift in RI of less than 0.0001. PC and PMMA, on the other hand, demonstrated a noticeable shift, with PMMA showing a ~10x higher shift in RI.

Ultra-Low Birefringence for VR Headsets

One application that has seen wide adoption of ZEONEX® is VR headsets. ZEONEX®'s glass-like performance combined with the weight reduction and moldability of a high performance plastic is highly beneficial for novel wearable lens shapes. Recent improvements include both screen resolution and the ability of optical materials to shape and transmit those visuals without distortion, across the user's entire field of view. While glass has the required optical properties, its weight and risk of breakage make it sub-optimal for a headset format.

ZEONEX® K26R was previously selected for headsets because of its high light transmission (greater than 91%), low water absorption and low birefringence, key to minimizing double refraction in VR systems where there is a demand for a wider field of view. The optical performance of ZEONEX® 360R was first validated in comparison to ZEONEX® K26R by evaluating the retardation of molded components. Light propagating through a material with lower birefringence results in a lower phase shift, or retardation. 3 mm thick plates with an area of 65 x 65 mm were molded using the optimal molding conditions for each grade (ZEONEX® 360R: resin temp. 260 ºC, mold temp. 112 ºC; ZEONEX® K26R: resin temp. 280 ºC, mold temp. 133 ºC). Using a measurement area of 57 x 57 mm, retardation analysis showed ZEONEX® 360R achieved a greater than 50% reduction in retardation compared to ZEONEX® K26R (Figure 2).

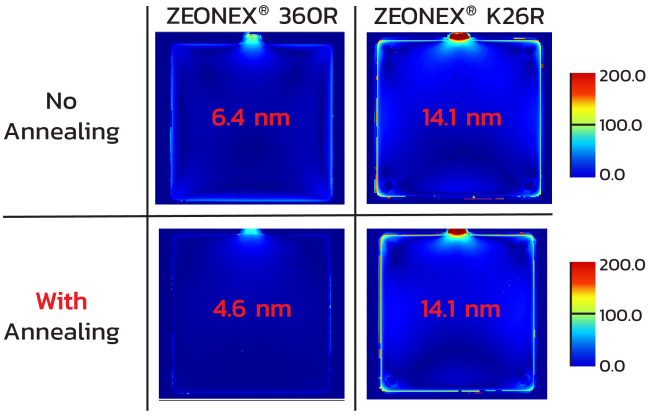

Figure 2. Retardation evaluation of ZEONEX® 360R vs. ZEONEX® K26R, without (top) and with (bottom) annealing.

Furthermore, the impact of annealing on reducing retardation was evaluated. Molded parts were annealed for 12hr at 90 ºC and 110 ºC respectively. While the ZEONEX® K26R demonstrated no improvement with annealing, the ZEONEX® 360R demonstrated a further reduction in the overall retardation value due to an increased uniformity over the molded piece, resulting in a retardation value of 4.6 nm. With the addition of an annealing step, very low retardation, and thus very low birefringence, can be achieved with this new grade. Overall, ZEONEX® 360R can reduce retardation and birefringence to ½ to 1/3 the value currently obtained with ZEONEX® K26R.

Further evaluation of ZEONEX® 360R demonstrated how optimizing annealing and cooling time can be used to achieve ultra-low retardation. A curved lens

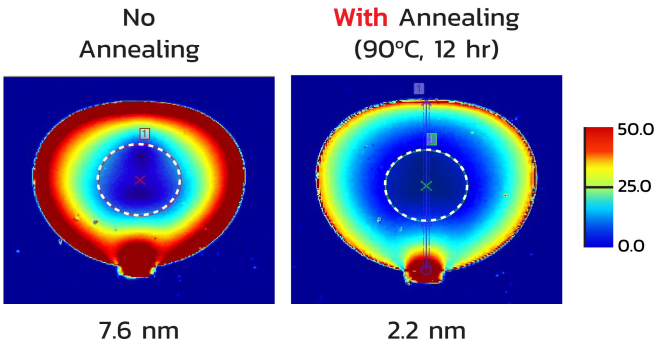

Figure 3. Reduction in retardation of ZEONEX® 360R through annealing. Area of analysis indicated by dashed circle.

with approximate diameter of 50-55mm and 3.34 mm thickness was molded under optimal conditions. After molding, various annealing and cooling profiles were explored. The impact of annealing time was almost saturated at 4 hrs, but by extending the annealing time to 12 hrs, with a cooling time of greater than 280s, a retardation of less than 3 nm was achieved (average of readings at 20 and 40 mm diameters). The average retardation over the core center of the lens (20 mm diameter) was 2.2 nm (Figure 3). The ultra-low retardation and improved optical performance of ZEONEX® 360R makes it a performance upgrade for VR applications.

Improved Light Transmittance for Blue Laser Applications

Blue Laser systems, including RGB laser projectors and Blu-Ray DVD systems, present their own challenges for optical materials and are another application in which ZEONEX® is commonly used. Lenses must maintain high % light transmission for extended periods of time, and at increased operating temperatures. Advances in projector technology such as development of RGB pure lasers have resulted in more energy-efficient light sources that last significantly longer. Materials selected for lenses must match that extended lifetime without any degradation in optical properties. ZEONEX® 350R has been a choice material for molding projection blue laser lenses because compared to other plastics it features >91% light transmission, from UV to NIR wavelengths, and it maintains optical performance even after extended irradiation. The performance of ZEONEX® 360R was compared to ZEONEX® 350R to determine optical stability during prolonged exposure to UV light and high temperature environments (Figure 4). Using a UV-VIS IR spectrophotometer the

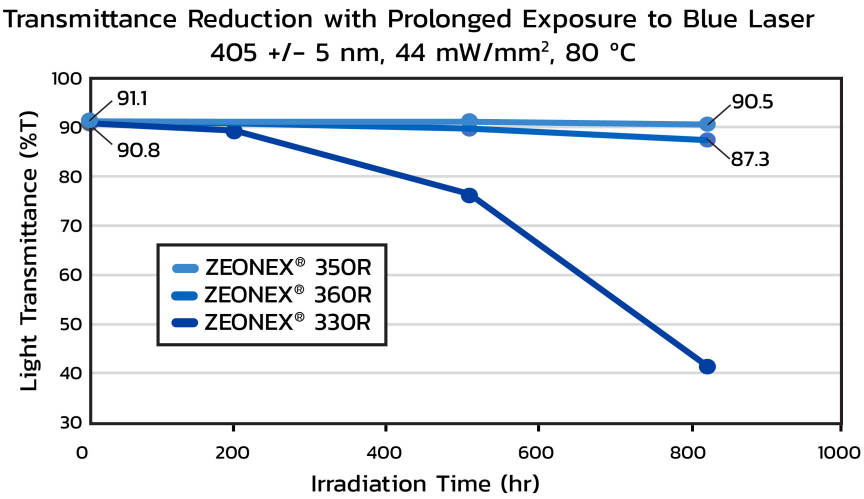

Figure 4. Resistance to environmental degradation and loss of % light transmittance from extended irradiation by blue laser.

transmission of ZEONEX® 360R, ZEONEX® 350R and ZEONEX® 330R were measured over 800hr of continuous irradiation by a 400 nm blue laser, while heated to 80 °C. ZEONEX® 330R showed a decrease in transmittance from 90.8% to 41.4%, indicating poor environmental stability. ZEONEX® 350R and ZEONEX® 360R, on the other hand, demonstrated excellent resistance to degradation, exhibiting less than 4% reduction in transmittance over the evaluation period and maintaining a % transmission of greater than 87%. The difference between ZEONEX® 350R and ZEONEX® 360R was less than 2% over the duration of the study. The performance of ZEONEX® 360R under continuous irradiation at 400 nm demonstrates its ability to replace ZEONEX® 350R in blue laser light applications.

Decreased Yellowing for Automotive HUDs and Micro-LED Headlights

Environmental stability against intense blue light is also required for various projection optical lenses that use LEDs, such as Automotive HUDs and collimator lenses for Micro-LED headlights. In addition to extended irradiation times, materials are often also exposed to raised temperature and humidity. These conditions can impact the performance of optical lenses, especially when applied in combination and for extended periods of time. In addition to a loss in %transmission as tested in Figure 4 (above), continuous exposure to high temperatures can also cause decreased optical performance due to resin oxidation and yellowing of the lens. The resistance of ZEONEX® 360R to yellowing at prolonged high temperature conditions was compared to existing ZEONEX® grades (Figure 5). After exposure to 80 and 100 °C for 1000 hr the yellow index was evaluated across the various resins, with ZEONEX® 360R exhibiting the smallest change. This was visible in both measurements from a color difference meter (left) as well as by naked eye (right). Compared to ZEONEX® 330R and 350R, ZEONEX® 360R shows equivalent or better performance under extended exposure to high temperatures.

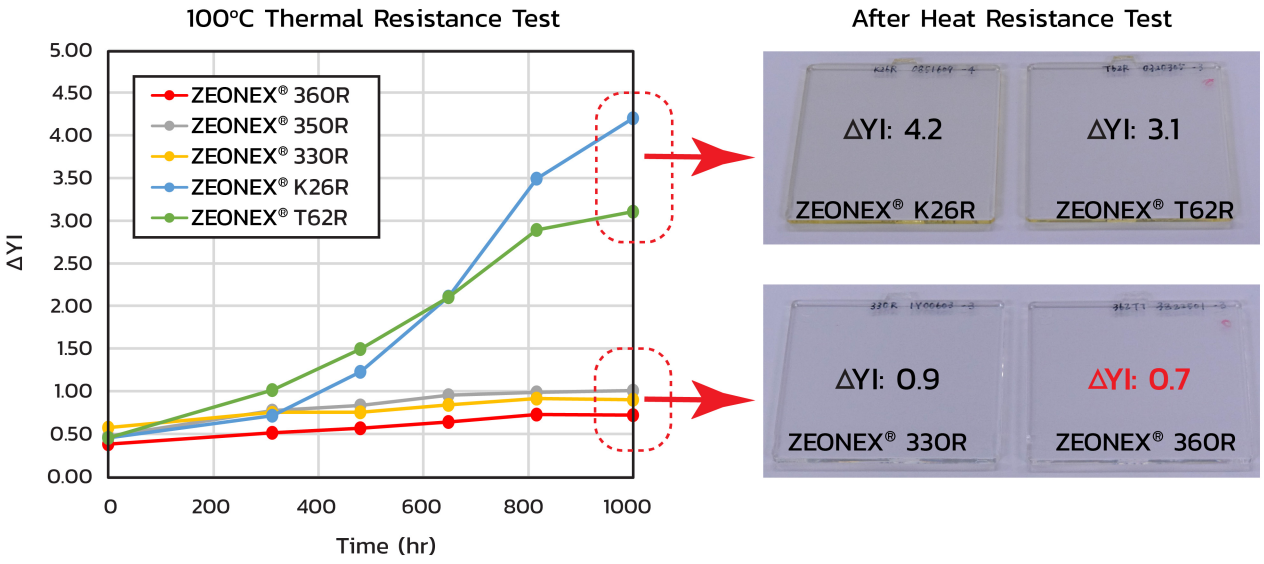

Figure 5. Resistance to oxidation and yellowing from extended exposure to high temperatures. Left: Measurement of the yellow index as a function of heat exposure time. Right: Images of test plates after exposure to 100 °C temperature for 1000 hr.

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Increased Capacity to 54,000MT/yr

As the world's leading supplier of Cyclo Olefin Polymer, Zeon has continued innovating to keep up with new applications and greater performance demands. Zeon's ZEONEX® and ZEONOR® resins range from Pharmacopeia-registered resins for drug storage, to optical resins for VR/AR and other lens applications, to ultra-wide retardation films for large-screen LCD TVs. With production of ZEONEX® and ZEONOR® currently underway on 4 lines, Zeon recently announced the addition of a 5th line, slated to come on-line in 2028, bringing capacity to 54,000MT/Yr. In addition, Zeon has developed a recycling process to recapture excess during manufacturing of ZeonorFilm®, which further increases the capacity and availability of ZEONEX® resins for other commercial applications. ZEONEX® 360R is another example of Zeon continuously refining production methods to maximize output while maintaining performance. ZEONEX® 360R takes advantage of capabilities within the Mizushima plant and, unlike ZEONEX® 350R, requires no additional processing. By eliminating these extra steps the production capacity of this new resin is much greater, both enabling larger programs and lowering the cost to customers. ZEONEX® 360R, Zeon's newest optical resin, maintains the high performance expected of optical ZEONEX®, with the high-capacity production capability only available at Zeon. Contact us today for more information.

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