

CR-39 Changes an Industry

Celebrating its 60th anniversary, this plastic monomer has gone from its challenging introduction to become the single largest selling lens material in the industry.

THE PLASTIC MONOMER CR-39® is celebrating the 60th anniversary of its patent. More than any other single material or process in the optical industry, it transformed the ophthalmic lens from a necessary medical device that no one wanted to wear into a dynamic, fashion-oriented business.

In 1973, I remember meeting up with Glen Cunningham, owner of Park Optical, a wholesale lab in West Los Angeles. He had a grin from ear to ear, and I couldn't resist asking the reason. I'll never forget his reply, "We finally got our CR-39 breakage under 33%!"

Such was the state of learning during the emergence of surfacing CR-39 after the 1972 FDA drop-ball ruling that precipitated the eventual growth of the product. As one early participant said, "If you stop to think about it, why would anyone want to have had anything to do with CR-39? We had problems from the packaging to final inspection. Then, once we learned, they came out with polycarbonate!" Welcome to the wholesale lab business.

Even today, CR-39 is still the single largest selling material in the industry accounting for almost half the lenses sold. The problems mentioned by the pioneers have all been solved through a combination of innovative machinery designs, improved processing materials, and seat-of-the-pants process engineering by the wholesale lab trade. To the young lab-rats out there, this is your heritage. Your obligation will be to pass along similar innovations to your successors.

—Jim Grootegoed

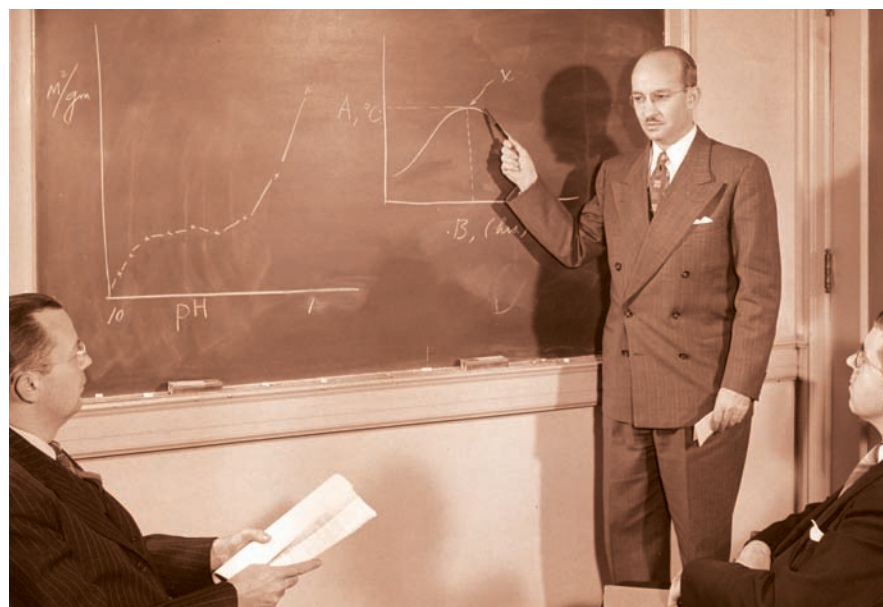
The following industry veterans recount their experiences from the early days of CR-39:

Richard Whitney, Manager, Ophthalmic Lens Design, Carl Zeiss Vision

If at first you don't succeed, try try

again . . . 39 times and you may hit the jackpot! So begins the story of how CR-39, the most successful and influential plastic material for ophthalmic lenses was born.

During World War II, the Columbia Southern Chemical Co. (a subsidiary of Pittsburgh Plate Glass Co.), was



(Above) Franklin Strain (standing) was the co-developer of allyl diglycol carbonate (CR-39 monomer) along with Frank Muskat. (Right) Sitting in PPG's Barberton, OH, shipping yard in 1945, this railroad tank car filled with 38,000 pounds of CR-39 monomer prompted the search for civilian uses for allyl diglycol carbonate and the development of lightweight plastic ophthalmic lenses.



looking for a plastic material that would be a suitable substitute for window glass. The company tried approximately 200 experimental polymers, and the 39th attempt proved to be an astounding success—but not for window glass. Columbia Resin's 39th for-

continued on page 11 ►

The Timeline of CR-39

1940 CR-39 monomer is developed by a research team at Columbia Southern Chemical Co., a wholly owned subsidiary of Pittsburgh Plate Glass Co. (now PPG).

1943 CR-39 resin first used for reflector

and searchlight applications.

1946 CR-39 monomer patent awarded to PPG's Irving E. Muskat and Franklin Strain.

1947 Armorlite Corp. forms and begins experimenting with CR-39 resin.

1952 LOS introduces ORMA® lenses made from Plexiglass resin in France.

1956 ORMA 1000 lenses made from CR-39 resin introduced in France.

1959 ORMA 1000 lenses worldwide debut.

1960 First plastic bifocals are cast. SOLA Optical formed and begins producing lenses made from CR-39 resin in Australia with 10 employees.



◀ *continued from page 8*

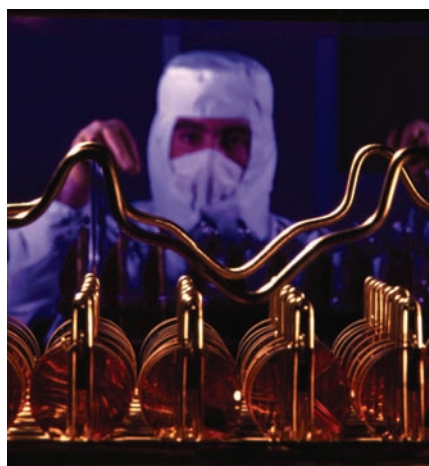
mulation became the material known as CR-39. The chemical name for CR-39 is allyl-diglycol carbonate. It is a thermosetting plastic which must be cast not molded.

The properties of CR-39 are unique and ideally suited for ophthalmic lens applications. There are a wide variety of reasons why 60 years after its introduction, this material still comprises almost half of the lens market in volume. CR-39 was also primarily responsible for the decline in glass sales, a trend which first began in the 1970s. The unique optical properties of CR-39—balance of index, Abbe values, clarity, density (half that of glass), tintability, and ease of processing—are attributes that have contributed to making it the most successful plastic material in the history of ophthalmic lenses.

The inherent abrasion resistance of CR-39, compared to most other optical plastics, has demonstrated that even without abrasion-resistant coatings it is acceptable in the marketplace for this feature. All common abrasion test methods in use today use CR-39 as a benchmark which other materials and coatings must meet or exceed.

The material's impact resistance also factors in its success. Unlike glass, which must be treated to comply with the FDA drop-ball test, CR-39 does not require such treatment. For this reason, batch testing rather than 100% testing was permitted by the FDA.

Finally, perhaps the most overlooked benefit to the widespread use



Casting lenses from CR-39 resin requires meticulous cleaning and care for the precise glass molds in which they are cast. Here, trays of completed lenses are removed from the oven following curing of the lens coating.

of CR-39 is the development of the casting process itself. Since CR-39 lenses are cast by using front and back molds (generally made from glass) with a supporting gasket, new configurations in lens designs were made practical for volume manufacturing applications. An early benefit to the casting process was the placement of the toric (cylinder) surface on the back surface of the lens nearer the eye. This optical benefit was not practical with glass. Toric surfaces were more easily applied to the front surface, which is why glass products were plus toric in their configuration. But with glass molds, minus toric's could now be transferred from the back glass mold to the lens. With the advent of CR-39, minus toric lenses became commonplace. Furthermore, progressive 'no-line' bifocal lens surfaces were made easier to fabricate in large quantities, as one progressive mold could

produce hundreds of lenses.

CR-39 has become the most influential and successful plastic material in the history of ophthalmic lenses. While other materials may one day surpass CR-39 in usage, it is hard to imagine that they could ever be more influential.

Pete Hanlin, ABOM, LDO, Training & Development Manager, Essilor Lens Group

As a lab manager in the Lancaster, PA, area, I was in one of the last holdouts for Crown glass (where there was a large Amish population who preferred glass lenses). The Coburn 2113 generator that we used had what is called a "fast change" wheel, and about once a week someone would forget to change the plastic wheel on the machine before running a glass lens through, creating a distinctive and memorable sound!

CR-39 has become the most influential plastic material in the history of ophthalmic lenses.

Perhaps the most interesting aspect of CR-39 was the manner in which the "laboratory attitude" evolved. Over the course of a few years, glass and CR-39 flipped positions. Glass

went from being the "easy" material to the irritating exception. Ironically, when polycarbonate came into the market, many of the initial complaints against CR-39, that of it being too sensitive to heat, too soft, or too difficult to process, now found a new target in polycarbonate. Suddenly, CR-39 was the "easy" material and polycarbonate was the irritating newcomer. I think it demonstrates how slow the ophthalmic industry can be to embrace change, especially in materials.

Emil "Toby" DePiero, Elite Labs, Los Angeles and Sacramento, CA (retired)

When CR-39 first came out, many of the lenses did not have the same sag as that marked on the boxes, so we had to sag 100% of the lenses. Calculations, established for glass, were different. We had to get a program that worked with the different index of refraction. Also, it wasn't uncommon to have lenses mispackaged—lefts for rights, different base curves, D25s in D28 boxes. You'd take the lenses out of the envelope or box, and they'd be different shades of yellow. And, many were already scratched, so 100% pre-inspection became pretty common.

Next, we had to learn how to block. The 157° glass-blocking alloy left surface waves. Before the 117° alloy came out, an available two-step epoxy was a mess to use. Also, before Surface Saver Tape, we typically used Aqua Net hair

continued on page 12 ▶

1961-66 SOLA begins exporting lenses made from CR-39 resin to Japan, England, France, Italy, India and other countries.

1969 La Lunette de Paris introduces ORMA 1000 lenses to the U.S.

1973 PPG's Barberton Technical Center conducts the first photochromic experiments with CR-39 monomer.

1974 3M develops scratch-resistant coating for lenses made from CR-39 resin.

1975 Lenses made from CR-39 resin now account for 15% of all lenses in the U.S.

1981 American Optical introduces Photolite photochromic lenses.

1983 PPG discovers new family of photochromics, the blue pyridobenzoxazines.

1986 PPG starts one-year \$1 million program to test technical and marketing feasibility of plastic photochromic lenses.

1988 PPG researchers at the company's technical center in Monroeville, PA, produce a prototype of plastic photochromic lenses.



◀ continued from page 11

spray to protect the front of the lens. Even with 117° alloy, we didn't know initially to let it cool for half an hour before generating, and we were still getting waves.

We were all used to surfacing glass using generating and edging wheels set up for glass, none of which worked with CR-39. I must have tried 20 different diamond tools in the Coburn 108 generator and it seems like 50 in the old A.I.T. Mark II edger before we found one that worked. Then, we had to contend with swarf, which was never an issue with glass.

We talked a lot among ourselves, competitors sharing "hints" with competitors. The problem was that everyone seemed to have a different recommendation. I must have tried a different fining and polishing pad every week for at least a year before finding ones that worked. The same with polish. We were told that heat and pressure were our enemies, so we kept lowering the head pressures on the cylinder machines to the point where they quit working. We learned to live with waves.

If we finally got lenses out of surfacing with the right power, we still had to edge them. If we weren't careful how we lowered the lens onto the diamond wheels, no matter how tight the lens was chucked, we'd torque the lens off axis. LEAP pads were supposedly our salvation, but the lenses twisted and it seems that every lens came in off-axis. Naturally, everyone's solution was to crank up the chuck pressure to the point where we left an



During World War II, the Columbia Southern Chemical Co. (a subsidiary of Pittsburgh Plate Glass Co.), was looking for a plastic material that would be a suitable substitute for window glass.

impression of the pad on the lens. But at least we were on-axis.

The edgers were made for smaller diameter 58mm to 65mm glass lenses, which didn't flex. Now, we were working with 72mm to 76mm flexible lenses. Low power jobs bent in the edger, and the bevel wandered all over the

edge of the lenses.

Rit® Dye's stock must have soared as we tried to learn how to tint the lenses. Depending upon the cure, we'd get different densities, even different colors in the same tint bath for the same amount of time. And then we were always concerned that

the lenses would come out blotchy from uneven curing.

Once delivered to our customers, we'd get them back falling out of the frames after they had shrunk. Metal frames were the worst.

Steve Drake, Director of Technical Services, Signet Armorlite, Inc.

CR-39 is nothing less than the foundation of the modern corrective lens market. It replaced Crown glass as the predominant material used in the U.S. during the 1970s. This was partly because of its lower cost to make multifocal lens blanks but also because of advantages for the wearer. For instance, its low weight made it comfortable to wear in almost any size. CR-39 could be tinted to your choice of colors and density. With the development of hardcoatings, its usage accelerated to almost 90% of corrective lenses.

So why CR-39? It has excellent optical clarity, and its uncoated abrasion resistance was much higher than other uncoated plastic lenses available in the '50s. Solutions to its disadvantages were refined, and labs developed compatible processing techniques.

Today, coatings are available for less abrasion-resistant plastic materials that offer advantages over CR-39. Still, CR-39 lenses make up the largest segment of any single lens material. Why? CR-39 is easy to mold, surface, edge, tint, hardcoat, and AR coat. Because it is also such a reliable and comfortable lens to wear, it will likely be used for a long time to come. ■

1990 Transitions Optical, Inc. is formed as a joint venture between PPG Industries and Essilor International and begins manufacturing Transitions® lenses.

1992 Researchers in Monroeville develop Transitions Plus comfort lenses, a faster acting photochromic lens.

1994 SOLA introduces Spectralite® optical lenses, the first photochromic high index lens.

1996 The third generation, Transitions III lenses are introduced in Spectralite and 1.56 high index.

2002 Trivex™ lens material and Generation IV Transitions lenses are developed and launched.

2006 60th anniversary of the CR-39 patent.