Sector focus
Manufacturing

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Success by Design Custom Glass Formulations

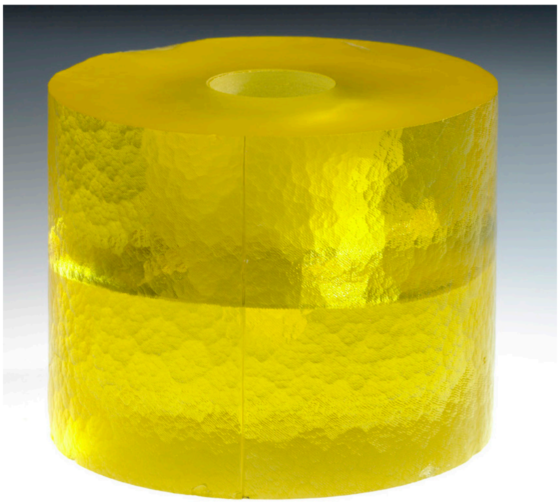
Glass has two main defining characteristics: it is an amorphous (non-crystalline) solid, meaning that there is no long-range order of the positioning of its molecules; and it exhibits a reversible transition from a hard, brittle state to a molten state when heated, without a pronounced change in material structure. These two characteristics provide the basis for the development of innovative glass formulations that can result in novel solutions to high-tech challenges.

Successful glass formulation requires a thorough knowledge of the raw materials to be used, an understanding of the dynamic interaction of these raw materials, and a great deal of experience with the formulation process itself. Complementing those skills is another critical element of glass formulation: a mindset that embraces the prospect of creating something new and unique that functions like no other material.

Meeting the application challenge

The decision by a researcher or manufacturer to investigate the feasibility of a custom glass formulation for a technical application usually follows his or her thorough review of the scientific literature and a period of in-house evaluation of existing materials. Given the desired characteristics and performance, what familiar or readily obtainable material will do the job? Only after all contenders are eliminated will a custom glass formulation be considered.

Today, specially formulated technical glass is found in a growing list of scientific fields (see box). More important than the particular field, however, is the performance that can be crafted into or onto the glass – performance that can potentially find application in any number of fields. The following represent just a few examples of how formulation can influence function.



Technical glass applications: A matter of balance

Virtually every technical glass application requires a balance of properties – a balance far more delicate than that found in most commercially available types of glass – that meet specific performance objectives. For example, the custom glass shown here needed to possess specific properties for its use in a new product, and it had to be easily machinable so that it could be manufactured in commercial quantities.

Several different glass compositions were produced and subsequently machined before the ideal formulation was achieved. This highly refined process of trial and error is typical of custom glass development; not until the science of formulation meets the real world of application testing does the winning combination emerge.

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HEAD OFFICE
Goodfellow Cambridge Limited
Ermine Business Park
Huntingdon, PE29 6WR
England

Tel: 0800 731 4653 (UK)
or +44 1480 424 800

Fax: 0800 328 7689 (UK)
or +44 1480 424 900

info@goodfellow.com
www.goodfellow.com

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Tailoring thermal properties

With careful selection of the type and proportions of raw material and adjustments to the formulation process itself, you can achieve the specific melt temperature required for a particular application. For example, durable glass has been made to melt at 400 oC, while other glass has been produced with a glass transition temperature below 150 oC. Even existing, non-custom glass can be altered to melt at 100 oC less than conventional container glasses.

Other thermal properties can also be modified in the technical glass development process. This is important, since matching the thermal stability and/or thermal expansion of the glass to other materials in a component or to the operational requirements of the application is critical to structural integrity and performance. A practical yet very high-tech example of control of thermal properties during formulation is found in the mirrors of the Hubble Space Telescope; they are made of ultra-low expansion glass and kept at a nearly constant room temperature (21oC) to prevent warping.

Blocking or channeling electromagnetic energy

As a coating or as a component, glass can be formulated to block or channel certain wavelengths of light (e.g., UV and infrared) as well as block radiation. Although glass coatings to block UV rays have long been available, glass is now being formulated with UV protection built right into the glass. A particularly sophisticated glass-based band pass filter has also been developed for tight infrared transmission. A less complex but perhaps more widely appreciated application of specially formulated glass is seen in the production of tinted beer bottles, used to protect their valued contents from flavor-killing 'light strike.'

Lead glass, though not as widely available as in years past, is still the most effective way to shield aerospace electronics from radiation during use. As for radiation detection, the addition of specific oxide dopants during glass formulation has resulted in specialized glass that is used in setting up and calibrating standard sets for X-ray fluorescence (XRF) spectroscopy.

Technical glass applications:
A matter of balance

Aerospace – instrumentation, radiationshielding devices, connectors

Automotive – light controls, sensors, air bag detonation systems

Electronics – sensors, capacitors, thermostats, coating of components
Telecommunications – fiber optic apparatus

Optics – specialty lenses, mirrors, infrared and UV filters

Fuel cells and microwaves – hermetic connectors, sealing components

Medical – bio-active coatings for orthopedic implants

Specially formulated glass is fundamental to the fiber optic industry

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Maximizing the power of light and color

For the exacting field of fiber optic communication, glass has been formulated to make Dense Wavelength Division Multiplexing (DWDM) substrates, used for greatly increased functional capacity of fiber optics strands. Specialists in technical glass formulation have also developed an innovative dichroic (Greek for 'two colors') glass that shifts from red to green depending on lighting and the environment. This is accomplished through in-glass oxide additions rather than more typical but less reliable multi-layer coatings. And for many applications, aesthetic and functional, selective rare earth doping of glass formulations can yield tight control of the desired final color.

Collaborative, but confidential

The development of any new material or component in a commercial setting is highly confidential. However, the process of development, of partnering with outside experts, is by nature intensely collaborative. Mutual trust and respect, energized by the thrill of developing something new that uniquely meets a need, can make the process a shared voyage of discovery that pays big dividends in performance and commercial success.

Matching the thermal properties of glass to metal in these hermetic seals is critical to successful performance.

Some properties that can be altered with custom glass formulation

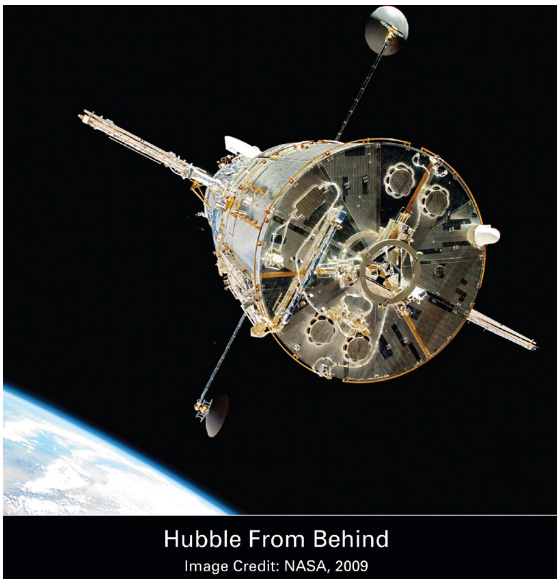
Thermal properties – melt temperature, stability, expansion for compatibility with other components

Physical durability – extreme hardness, abrasion resistance for wear-resistant coatings and components

Color – aesthetic and functional, for glasses and glazes

Chemical durability – for resistance to acids and bases

Refractive index matching and dispersion – for optical and fiber optic applications



Mirrors on the Hubble Space Telescope are made of ultra-low expansion glass. Image credit: NASA, 2009

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