Styrene-Acrylonitrile Copolymer

Welding

BASF AG: Luran (features: transparent)

Luran extruded stock and mouldings can be welded together by hot-shoe, rotational and ultrasonic techniques.

Reference: *Luran Product Line, Properties, Processing,* supplier design guide (B 565 e/10.83) - BASF Aktiengesellschaft, 1983.

Ultrasonic Welding

Dow Chemical: Tyril (features: transparent)

Excellent results are obtained by sonic welding parts molded with Tyril to each other, and also to parts molded of ABS.

Reference: *Tyril SAN Resins Engineering and Fabrication Guidelines,* supplier design guide (301-01318-290 RID) - Dow Chemical, 1990.

Dow Chemical: Tyril 880B (note: high acrylonitrile content); **Tyril 990** (note: low acrylonitrile content)

This study was designed to identify which resins could be effectively welded to themselves and other resins, and to identify the maximum bond integrity. Besides looking at the weld strength of various thermoplastic resins, this study explores the effects of gamma radiation and ethylene oxide (EtO) sterilization on the strength of these welds. A wide variety of resins used in the healthcare industry were evaluated including: ABS, polycarbonate (PC), polycarbonate/ ABS blends (PC/ABS), styrene acrylonitrile (SAN), thermoplastic polyurethanes (TPU), rigid TPU's (RTPU), high impact polystyrene (HIPS), and general purpose polystyrene (GPPS).

The strength of customized "I" beam test pieces was tested in the tensile mode to determine the original strength of each resin in the solid, nonbonded test piece configuration. Data from this base line testing was used to determine the percent of original strength that was maintained after welding. Only amorphous resins were used in this study. The most commonly used energy director for amorphus resins, a 90° butt joint, was used as the welding architecture.

Every attempt was made to make this a "real world" study. The aim during the welding process was to create a strong weld, while maintaining the aesthetics of the part. One of the most important factors in determining whether or not a good weld had been achieved was the amount of flash, or overrun noticed along both sides of the joint. Another characteristic of a good weld was a complete wetting of the cross sectional weld area. The problem here, however, was that only clear polymers used as the top piece, allowed the whole weld to be seen.

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Almost all resins involved in the study could be welded together with some degree of success (except for thermoplastic urethanes which didn't bond to the polystyrenes). Overall, it apppeared resin compatibility and the ability to transfer vibrational energy through a part and not close glass transition temperatures, were the overriding characteristics that lead to the best welds. Although not shown in this study, it should be noted that the ability for a resin to be welded is also a function of the architecture of the ultrasonic weld. Some resins which welded well in the arhitecture used for this study may not weld well with other architectures.

The SAN resins ultrasonically bonded, in some fashin, to all the resins in this study. Due to the extreme notch sensitivity of SAN, numerous premature failures occurred during the strength testing. This was most evident in bonds with other brittle polymers such as GPPS. This problem could possibly be eliminated by changing the test piece design. However, from a "real world" perspective, this may be a phenomenon to keep in mind when designing parts that involve SAN.

The SAN grade with the lower acrylonitrile (AN) content showed a tendency to produce ultrasonic bonds with higher strengths overall versus the higher AN content grade. On the other hand, the low AN grade showed a tendency to lose strength after EtO sterilization, whereas the high AN grade did not show this same trend. It is well known that AN imparts improved chemical resistance in styrenic polymers. This explains why the higher AN content resin provides a better barrier to EtO attack. Gamma sterilization didn't seem to affect the SAN bond integrity during this short term study.

Reference: Kingsbury, R.T., *Ultrasonic Weldability of a Broad Range of Medical Plastics,* ANTEC 1991, conference proceedings - Society of Plastics Engineers, 1991.

Adhesive and Solvent Bonding

BASF AG: Luran (features: transparent)

The difference in the resistance of the various Luran resins to aromatic hydrocarbons is evident in bonding with solvents: Luran 358 N and 368 R can be readily bonded with toluene, but stronger solvents, e.g., ethyl acetate, dichloroethylene and cyclohexanone, are required for Luran 378 P and 388 S. If Luran mouldings are to be bonded together by solvents, they must have been produced from the same resin or from the resins with similar acrylonitrile contents, i.e., Luran 358 N to 368 R and Luran 378 P to 388 S.

Reference: *Luran Product Line, Properties, Processing,* supplier design guide (B 565 e/10.83) - BASF Aktiengesellschaft, 1983.

Dow Chemical: Tyril (features: transparent)

Solvent Welding: Parts made of Tyril resins may be welded to each other with a number of effective solvents. Methylene chloride is commonly used if a fast drying solvent adhesive is desired. Methyl ethyl ketone, and a mixture of 30% methyl methacrylate monomer and 70% butyl acetate, are effective medium drying solvent adhesives. To add body to the adhesive, these solvents can accept up to 15% (wt.) of pellets of Tyril resin.

Adhesive Bonding. Many common rubber-based adhesives may be used to bond parts made with Tyril to a variety of non-plastic materials such as metal, wood, and glass. Similarly, successful adhesive bonds can be made between parts of Tyril and parts molded of plasticized PVC, Saran resin or cellulosics. (note: polystyrene parts are very difficult to adhesive-bond to those same plastics. Where this is a problem, molding the part of Tyril can be an effective answer. In choosing the adhesive, test to be certain there will be no bonded part failure caused by stress cracking.)

Reference: *Tyril SAN Resins Engineering and Fabrication Guidelines,* supplier design guide (301-01318-290 RID) - Dow Chemical, 1990.

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Dow Chemical: Tyril (features: transparent)

In tests conducted to evaluate the bondability/compatibility of plasticized PVC tubing to rigid, transparent thermoplastics, results suggest to avoid straight MEK or blends with high amounts of methylene chloride for use with SAN. Crazing was quite pronounced when straight methylene chloride or acetone were used as solvents. The SAN luers tested with surprisingly high peak loads. Results suggest that the solvent of choice for SAN is a blend of MEK in cyclohexanone in ratios ranging between 10:90 and up to 50:50.

Reference: Haskell, A., *Bondabilitly/Compatibility of Plasticized PVC to Rigid, Transparent Thermoplastics,* ANTEC 1989, conference proceedings - Society of Plastics Engineers, 1989.

Adhesive Bonding

Monsanto: Lustran 31

A study was conducted to test for bond strength on a representative matrix of commonly used plastics and the adhesives best suited to them. For many of the plastics evaluated, the effect of polymer composition on bond strength was evaluated by compounding plastic formulations with each of the most commonly used additives and fillers for that plastic; common grades were used for the remaining resins. The effect of each additive and filler was determined by comparing the bond strength achieved with the specially compounded formulations to that of the neat plastic. In addition, the effect of surface roughening and chemical treatment of the plastic surface on bond strength was examined.

The block-shear (ASTM D 4501) test was chosen as the test method because it places the load on a thicker section of the test specimen that can withstand higher loads before experiencing substrate failure. In addition, the geometry of the test specimens and the block-shear fixture helps minimize peel and cleavage forces in the joint. How well the block-shear test method reflects the stresses that an adhesively bonded joint will experience in real world applications should be considered. Also, limitations on the data due to the variety of additives and fillers used by different companies should not be ignored.

Prism 401 and Super Bonder 414, both cyanoacrylate adhesives, created bonds stronger than the SAN substrate for all the formulations which were evaluated, with the exception of the formulation containing the flame retardant additive. Loctite 3105, a light curing acrylic adhesive, achieved the second highest bond strengths. Depend 330, a two-part no-mix acrylic adhesive, and Black Max 380, a rubber toughened cyanoacrylate adhesive, achieved the lowest bond strengths.

Surface Treatments
Surface roughening caused either no effect or a statistically significant increase in the bond strengths achieved on SAN. The use of Prism Primer 770, in conjunction with Prism 401, caused a statistically significant decrease in the bond strengths achieved on SAN for all the formulations which were evaluated.

Other Information
SAN is compatible with acrylic adhesives but can be attacked by their activators before the adhesive has cured. Any excess activator should be removed from the surface immediately. SAN is incompatible with anaerobic adhesives. Recommended surface cleaners are isopropyl alcohol and Loctite ODC Free Cleaner 7070.

Table 67.1: Shear strengths of SAN to SAN adhesive bonds made using adhesives available from Loctite Corporation. Values are given in psi and (MPa).[b,c]

Plastic Material Composition (Monsanto Lustran 31)		Loctite Adhesive					
		Black Max 380 rubber toughened cyanoacrylate (200 cP)	**Prism 401** surface insensitive ethyl cyanoacrylate (100 cP)	**Prism 401/ Prism Primer 770** polyolefin primer for cyanoacrylate	**Super Bonder 414** general purpose cyanoacrylate (110 cP)	**Depend 330** two-part no-mix acrylic	**Loctite 3105** light cure acrylic (300 cP)
Unfilled resin	3 rms	500 (3.5)	3800 [a] (>26.2) [a]	450 (3.1)	3650 [a] (>25.2) [a]	800 (5.5)	2800 (19.3)
Roughened	18 rm	>850 [a] (>5.9) [a]	>3800 [a] (>26.2) [a]	1150 (7.9)	>3650 [a] (>25.2) [a]	800 (5.5)	>2900 [a] (>20.0) [a]
UV stabilizer	0.31% Tinuvin 770 0.31% Tinuvin 328	>2050 [a] (>14.1) [a]	>3800 [a] (>26.2) [a]	450 (3.1)	>5950 [a] (>41.0) [a]	>1200 [a] (>8.3) [a]	2800 (19.3)
Flame retardant	4% Saytex HBCD-SF 1% Antimony Oxide	500 (3.5)	1850 (12.8)	>1000 [a] (>6.9) [a]	1550 (10.7)	800 (5.5)	>2800 [a] (>19.3) [a]
Impact modifier	29% Paraloid EXL3330	1000 (6.9)	>3800 [a] (>26.2) [a]	>1450 [a] (>10.0) [a]	>3650 [a] (>25.2) [a]	>1100 [a] (>7.6) [a]	2800 (19.3)
Lubricant	0.1% Calcium Stearate 24-46	500 (3.5)	>3800 [a] (>26.2) [a]	>750 [a] (>5.2) [a]	>3650 [a] (>25.2) [a]	800 (5.5)	2800 (19.3)
Internal mold release	5% Mold Wiz INT-33PA	750 (5.2)	>3800 [a] (>26.2) [a]	450 (3.1)	>3650 [a] (>25.2) [a]	800 (5.5)	1750 (12.1)
Glass filler	17% Glass Type 3540	500 (3.5)	>3800 [a] (26.2) [a]	450 (3.1)	>4550 [a] (>31.4) [a]	800 (5.5)	2800 (19.3)
Colorant	1% OmniColor Fuschia	500 (3.5)	>3800 [a] (>26.2) [a]	1400 (9.7)	>3650 [a] (>25.2) [a]	>900 [a] (>6.2) [a]	2800 (19.3)
Antistatic	3% Armostat 550	>1850 [a] (>12.8) [a]	>3800 [a] (>26.2) [a]	450 (3.1)	>3650 [a] (>25.2) [a]	800 (5.5)	>3000 [a] (20.7) [a]

[a] The force applied to the test specimens exceeded the strength of the material resulting in substrate failure before the actual bond strength achieved by the adhesive could be determined.
[b] All testing was done according to the block shear method (ASTM D4501).
[c] For more information on data presented in this table, contact Loctite Corporation at 800-562-8483 (1-800-LOCTITE). Request the “Design Guide for Bonding Plastics.”

Reference: *The Loctite Design Guide for Bonding Plastics,* supplier design guide (LT-2197) - Loctite Corporation.

Solvent Bonding

Cheil Industries: Starex

Solvent welding is typically practiced with various solvents such as methyl ethyl ketone (MEK), acetone, styrene monomer and trichloroethylene. It is also desirable to solute about 5% of SAN resin with these chemicals.

Reference: *Starex SAN,* supplier design guide - Cheil Industries.

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