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ADHESIVE EVALUATION OF NEW POLYIMIDES

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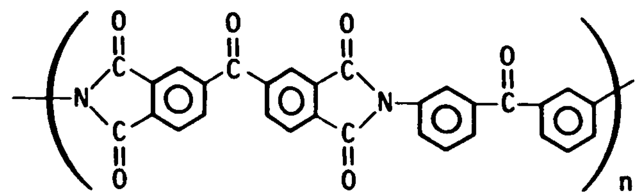
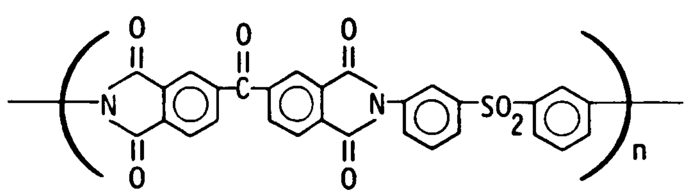
There are few materials available which can be used as aerospace adhesives at temperatures in excess of 200°C. During the past 10-15 years, the Materials Division at NASA Langley Research Center has developed several novel high temperature polyimide adhesives to fulfill the anticipated needs of the aerospace industry. These developments have resulted from fundamental studies of structure-property relationships in polyimides. Two materials that have exhibited exceptional adhesive properties are LARC-TPI (Langley Research Center Thermoplastic Imide) and PISO2 (a thermoplastic polyimidesulfone). The structures of these are illustrated.

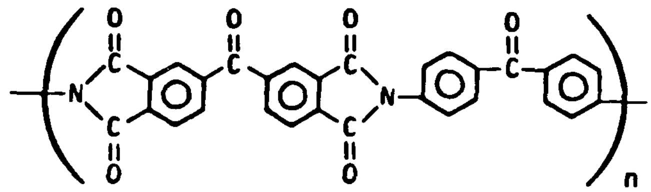


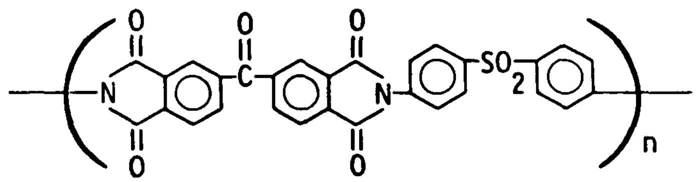
LARC-TPI



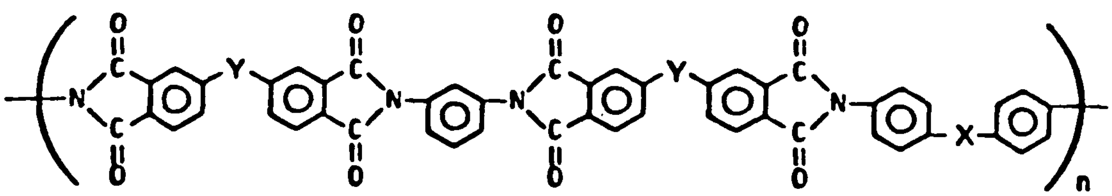
PISO2

In examining these structures one should notice that the backbones are identical with one exception - a carbonyl group in LARC-TPI and a sulfone group in PISO2. The primary characteristic that imparts the thermoplastic nature, and hence good adhesive properties, to these systems is the degree of flexibility along the backbone. In this regard, the flexibility is introduced via the carbonyl bridging group in the anhydride-derived portion of the chain and from the sulfone and carbonyl groups in the diamine-derived portion of the chain. In addition a key factor is the meta-oriented linkage to the benzene rings in the amine-derived segments. The corresponding systems with para-oriented linkages exhibit very little thermoplasticity. The structures are shown below for comparison.



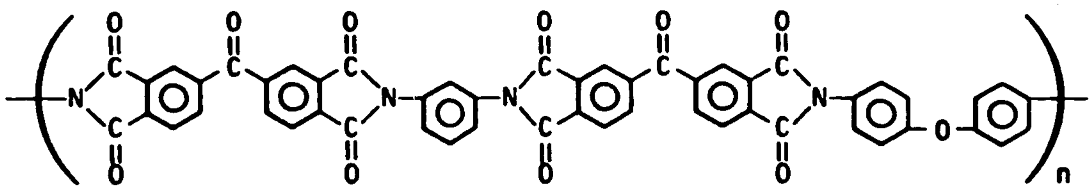


A recent research program at NASA Langley has involved the synthesis and evaluation of copolyimides which incorporate both flexibilizing bridging groups and meta-linked benzene rings. This activity was undertaken in order to develop systems based on low cost, readily available monomers. The approach involved the preparation of copolyimides of the following structure:

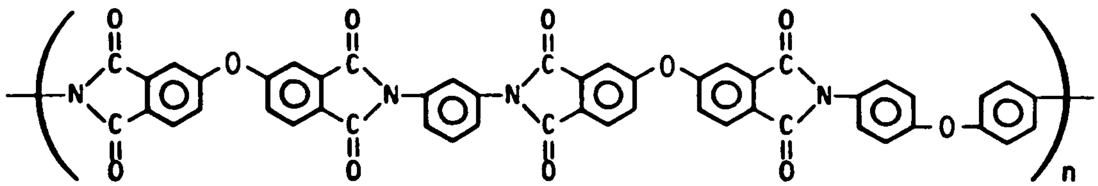


In the cases studied to date, x is an oxygen and y is either an oxygen or a carbonyl. Models of this system and of the LARC-TPI and PISO2 were prepared and compared. All systems exhibited similar long range flexibility with the LARC-TPI and PISO2 exhibiting more uniform short range flexibility.

The two copolyimides that have been evaluated as adhesives for bonding a titanium alloy [Ti(6Al-4V)] are as follows:



LARC-STPI



STPI-LARC-2

A comparison of room temperature and 400°F (204°C) lap shear strengths are shown in Table I below.

TABLE I

	Lap Shear Strength, psi		
Adhesive	RT	400°F (204°C)	Tg, °C
LARC-TPI	4791	3660	260
PIS02	3650	2920	273
LARC-STPI	3858	3626	283
STPI-LARC-2	5111	3890	279

We chose to age the LARC-STPI system at 232°C for comparison with the data base of LARC-TPI. A comparison of the two systems is shown in Table II.

TABLE II

Aging Time at 232°C (450°F), Hours	Lap Shear Strength,* psi	
	LARC-TPI	LARC-STPI
0	1970	3580
168	2840	3590
2500	3390	2570
5000	3440	1420

*Tested at 232°C (450°F)

As seen in the table, the copolymer does not perform as well as the LARC-TPI. After the postcure effect, the LARC-TPI retained its strength whereas the LARC-STPI copolymer retained only 40 percent of its highest strength value. This poor thermooxidative performance is possibly due to the amine portions of the LARC-STPI. The amines used in this polymer should have more tendency to oxidize than the benzophenone system used for LARC-TPI.

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16. Abstract

During the past 10-15 years, the Materials Division at NASA Langley Research Center (LaRC) has developed several novel high temperature polyimide adhesives for anticipated needs of the aerospace industry. These developments have resulted from fundamental studies of structure-property relationships in polyimides. Recent research at LaRC has involved the synthesis and evaluation of copolyimides which incorporate both flexibilizing bridging groups and meta-linked benzene rings. The reason for this activity was to develop systems based on low cost, readily available monomers. Two of these copolyimides evaluated as adhesives for bonding titanium alloy, Ti(6Al-4V), are identified as LARC-STPI and STPI-LARC-2. Lap shear strength (LSS) measurements were used to determine the strength and durability of the adhesive materials. LSS results are presented for LARC-TPI and LARC-STPI lap shear specimens thermally exposed in air at 232°C for up to 5000 hrs. LARC-TPI was shown to perform better than the copolymer LARC-STPI which exhibited poor thermooxidative performance possibly due to the amines used which would tend to oxidize easier than the benzophenone system in LARC-TPI.

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