# NASA TECH BRIEF

*Marshall Space Flight Center*



## Curable Polyphosphazenes

**The problem:**

Most organic polymers are usable only over a limited temperature range. Most lose their flexibility at low temperatures, and many decompose at high temperatures. Instability at high temperatures is a particular problem because many polymers must be cured at 150° C or higher.

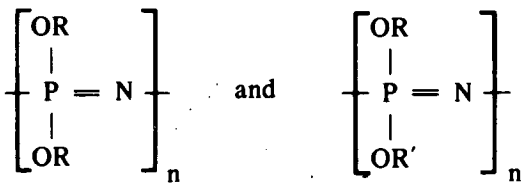
**The solution:**

A class of polyphosphazene polymers has been developed which can be cured at moderate temperatures by the action of moisture. In addition, the polymers maintain flexibility when exposed to low temperatures.

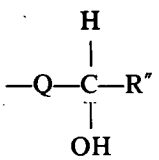
**How it's done:**

Polyphosphazenes are inorganic polymers in which carbon backbone is replaced by alternating atoms of phosphorus and nitrogen, forming linear chains to which various groups can be attached. At least some of the groups must contain OH functionality.

Basically, linear phosphazenes are used in which the skeletal chains comprise randomly repeating units represented by the general formulas:




Here the R's are the same or different monovalent radicals, such as alkyls, substituted alkyls, fluoroalkyls, aryls, substituted aryls, or arylalkyls. R′ is a monovalent aliphatic or aromatic group or substituted alkyl or aryl group containing a functional OH group and is represented by the formula




Q is either $(CH_2)_n$ or $—C_6H_4X(CH_2)_m$. The $X(CH_2)_m$ group may be meta or para, n is an integer from 1 to 6, and m is an integer from 1 to 3. The X is O (oxygen) or $CH_2$; R″ is H or a lower alkyl group with up to 4 carbon atoms. The ratio of R′:R is between 0.5 to 99.5 and 35 to 65, and n is an integer from 10 to about 50,000.

In general, the polyphosphazenes are reacted with an excess of polyfunctional isocyanate producing a soluble product which cures at moderate temperatures in the presence of moisture. The ratio of NCO/OH essential to achieve this result depends on the reactivity of the isocyanate and is usually above 1.5. The resulting isocyanate-terminated prepolymers react readily with moisture present in the air at room temperatures. The —NCO group is converted to an —NH—COOH group which decarboxylates to an active $—NH_2$ group suitable for crosslinking.

(continued overleaf)

**Note:**

Requests for further information may be directed to:

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**Patent status:**

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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