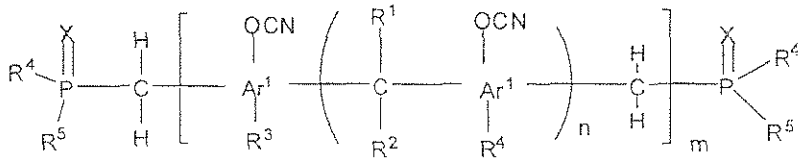
Summary

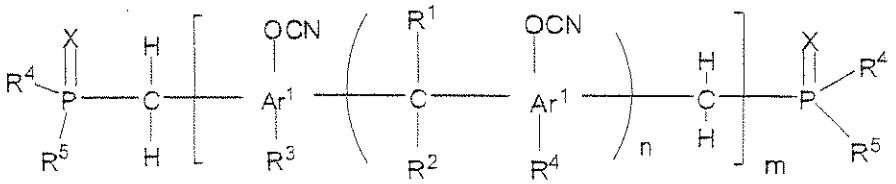
Embodiments of the present disclosure provide a thermosetting monomer comprising at least two of an aryl-cyanato group and at least two of a phosphorus group. For the various embodiments, such a thermosetting monomer can be represented by a compound of Formula (I):

Formula (I)



wherein m is an integer from 1 to 20; wherein n is an integer from 0 to 20 with the proviso that when n is 0 then m is an integer from 2 to 20; wherein X is selected from the group consisting of sulfur, oxygen, a lone electron pair, and combinations thereof; wherein each R^1 and R^2 is independently a hydrogen, an aliphatic moiety having 1 to 20 carbon atoms, an aromatic hydrocarbon moiety having 6 to 20 carbon atoms, where the aliphatic moiety and the aromatic hydrocarbon moiety can be joined to form a cyclic structure; wherein R^3 is selected from the group consisting of a hydrogen, an aliphatic moiety having 1 to 20 carbon atoms, an aromatic hydrocarbon moiety having 6 to 20 carbon atoms, $R^4R^5P(=X)CH_2$-, and $ROCH_2$-, where R is an aliphatic moiety having 1 to 20 carbon atoms; wherein each R^4 and R^5 is independently an aliphatic moiety having 1 to 20 carbon atoms, an aromatic hydrocarbon moiety having 6 to 20 carbon atoms, where the aliphatic moiety and the aromatic hydrocarbon moiety can be joined to form a cyclic structure, RX-, or wherein R^4 and R^5 together are Ar^2X-; and wherein each Ar^1 and Ar^2 is independently a benzene, a naphthalene, of a biphenyl.

In a first aspect, there is provided a thermosetting monomer comprising at least two of an aryl-cyanato group and at least two of a phosphorus group, where the thermosetting monomer is represented by a compound of Formula (I):

Formula (I) 

wherein m is an integer from 1 to 20;

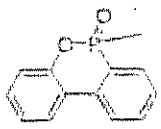
wherein n is an integer from 0 to 20 with the proviso that when n is 0 then m is an integer from 2 to 20;

wherein X is selected from the group consisting of sulfur, oxygen, and a lone electron pair;

wherein each R^1 and R^2 is independently a hydrogen, an aliphatic moiety having 1 to 20 carbon atoms, or aromatic hydrocarbon moiety having 6 to 20 carbon atoms, where the aliphatic moiety and the aromatic hydrocarbon moiety can be joined to form a cyclic structure;

wherein R^3 is selected from the group consisting of a hydrogen, an aliphatic moiety having 1 to 20 carbon atoms, an aromatic hydrocarbon moiety having 6 to 20 carbon atoms, $R^4R^5P(=X)CH_2$-, and $ROCH_2$-, where R is an aliphatic moiety having 1 to 20 carbon atoms; and

wherein each R^4 and R^5 is independently an aliphatic moiety having 1 to 20 carbon atoms, an aromatic hydrocarbon moiety having 6 to 20 carbon atoms, where the aliphatic moiety and the aromatic hydrocarbon moiety can be joined to form a cyclic structure, RX-, or wherein R^4 and R^5 together with the P that R^4 and R^5 are attached to form a compound of formula II:

; and

wherein Ar^1 is independently a benzene, a naphthalene, or a biphenyl.

The various embodiments also include a composition that includes the thermosetting monomer of the present disclosure. For the various embodiments, the composition having the thermosetting monomer can be used to prepare a resin sheet, a resin clad metal foil, a prepreg, a laminated board, or a multi-layer board, among other items. In an additional embodiment, the composition having the thermosetting monomer of the present disclosure can further include a resin, such as a bismaleimide-triazine epoxy resin or FR5 epoxy resin, where the thermosetting monomer of the present disclosure and the resin can be used to prepare the aforementioned items.

In a second aspect, there is provided a composition, comprising the thermosetting monomer as defined herein.

For the various embodiments, a process for making the thermosetting monomer can include first formation of a phosphorus-substituted polyphenol by condensing an active phosphorous compound ($H\text{-}P(=X)R^4R^5$) with and an etherified resole followed by conversion to a polycyanate with cyanogen halide and a base. In the case where the etherified resole is butyl ether bisphenol-A