[0019] In still a further example, United States Patent Publication 2015/0159368 describes a liquid intumescent coating with at least one ethylenically unsaturated monomeric polymer resin. The resin is cured by free radical polymerization adhesively bound onto a reinforcement structure, such as inorganic fabric.

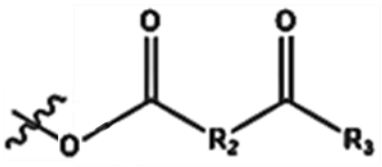
[0020] In contrast, examples of coating compositions specifically engineered for cold-weather conditions are also known. For example, United States Patent 5,070,119, European Patent EP0477840B1, United States Patent Publication 2018/0079915 and International Patent Publications WO2010131037A1 and WO2018227458A1 all provide examples of such materials. Silicone-based alternative coatings are also sold under the trade names SILOTHERM from Elox-Prom (Moscow, Russia) and NULLFIRE from Tremco-Illbruck Ltd. (London, England).

SUMMARY

[0020a] In a first aspect, the present disclosure refers to a flexible resin system for epoxy intumescent coating compositions comprising:

at least one epoxy resin and an acetoacetate polyacetatoacetate (AcAc) functional polymer combined with an amine functional curing agent to form a cured flexible resin system that cures within 24 hours with a shore D hardness of at least 2.5;

wherein the AcAc functional polymer includes at least one terminal AcAc unit as follows:



in which R_2 is $–CH_2-$ and R_3 is $–CH_3$; and

wherein the cured flexible resin system: (i) when equilibrated to -60° C, does not crack after a manual bend test, and (ii) when immersed in water for at least 5 days, gains less than 7.5 wt.% (relative to a dry weight of the coating prior to being immersed).

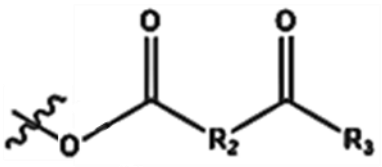
[0020b] In another aspect, the present disclosure refers to an intumescent coating composition resistant to cracking at -60° C and water absorption, the composition comprising:

a first part comprising at least one epoxy resin, an acetoacetoxy polyacetoacetate (AcAc) functional polymer, and an optional liquid plasticizer;

a second part comprising at least one amine functional curing agent including polyamide having an H eq.wt. between 90 and 110, and an optional liquid plasticizer;

an intumescent ingredient package including an acid source, an optional a carbon source, and a gas source; and

wherein the AcAc functional polymer includes a terminal AcAc unit as follows



in which R_2 is $–CH_2-$ and R_3 is $–CH_3$.

[0021] An intumescent coating composition is able to repeatedly withstand extremely low temperatures (i.e., -60° C) without cracking while retaining sufficient durability (as demonstrated by resistance to water absorption), acceptable cure times, shore D hardness, and an expandable, well-adhered, foamed char layer. In one example, the coating composition balances the flexibility of an epoxy resin and curing agent combination by incorporating an internally flexibilised acetoacetoxy polyacetoacetate (AcAc) terminal unit in a polymer, such as an AcAc functional epoxy polyester block copolymer or an AcAc functional dimer fatty acid / polyester block copolymer. In another example, a synergistic balance of specific epoxy resin binders and amine functional curing agents—with or without catalytic accelerators—also achieves these goals. In further example, a resin system relies upon either of these same principles/approaches.

[0022] The compositions and coatings produced by these compositions have particular utility in providing intumescent protections. Thus, the cured coating should be at least 20 mm,

capable of curing at 23° C to a Shore D hardness of least 5.0 in less than 24 hours, at least 25 in less than 7 days, and at least 35 in less than 14 days. The water (deionized, natural, or salt water) absorption for the cured coating is at least less than 10.00 wt.% and, more preferably, less than 5.0 wt.% after 28 days of submersion and at least less than 3.00 wt.% and, more preferably, less than 1.00 wt.% after 5 days of submersion (with all wt.% relative to the dry weight of the coating before submersion). Further still, the cured coating can withstand temperatures of - 55° C or less (even as low as – 67.5° C) without cracking, and this durability applies for at least 5 and, more preferably, at least 12 complete temperature cycles from its lowest point back up to ambient conditions. Test procedures and further quantitative and qualitative details are provided in the description and examples below, all of which specifically inform and augment examples of this present disclosure.

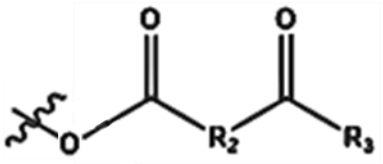
[0023] One example of the present disclosure encompasses a flexible resin system appropriate for use with epoxy intumescent coating compositions. This resin system may include any combination of the following features (in addition to all of the other details disclosed within this description):

- at least one epoxy resin and an acetoacetate polyacetatoacetate (AcAc) functional polymer combined with an amine functional curing agent to form a coating that cures within 24 hours with a shore D hardness of at least 2.5 or that cures within 24 hours at 23° C with a shore D hardness of at least 5.0;
- a catalyst selected from: dipropylenetriamine, benzyldimethylamine, n,n-dimethylpropylamine, bis(dimethylaminoethyl)ether, bis-n,n-dimethylethanolaminether, 1,3-propanediamine, 1,3-bis[3-(dimethylamino)propyl]urea, N'-(3- (dimethylamino)propyl)-N,N-dimethyl, 1,4-diazabicyclooctane (DABCO), 2-(2-(2-dimethylaminoethoxy)-ethylmethylamino)-ethanol, 1,8-diazabicyclo[5.4.0]undec-7-en (DBU), 1,3-propanediamine, N'-(3-(dimethylamino)propyl)-N,N-dimethyl 1,5-diazabicyclo[4.3.0]non-5-en, 1,1,3,3-

- wherein the acetoacetate polyacetoacetate functional polymer has any of the structural features shown in Figures 1A through 1D.

[0024] A separate example of the present disclosure specifically contemplates intumescent coating composition resistant to cracking at -60° C and water absorption. It includes any combination of the following features (in addition to all of the other details disclosed within this description):

- a first part comprising at least one epoxy resin, an acetoacetoxy polyacetoacetate (AcAc) functional polymer, and an optional liquid plasticizer;
- a second part comprising at least one amine functional curing agent including polyamide having an H eq.wt. between 90 and 110, and an optional liquid plasticizer;
- an intumescent ingredient package including an acid source, a carbon source, and a gas source;
- wherein the AcAc functional polymer includes a terminal AcAc unit as follows



in which R_2 is $–CH_2-$ and R_3 is $–CH_3$;

- wherein the intumescent ingredient package further comprises at least one of: a nucleating agent, fibres, a plasticiser, rheology modifiers, wetting/dispersion additives, and any combination thereof;
- wherein every chain in the AcAc functional polymer ends with the terminal AcAc unit;
- wherein the AcAc functional polymer consists of at least 0.50 wt.% relative to a combined mass of the composition and, more preferably, about 5.00 to about 25.00 wt.% relative to the combined mass of the composition;