ELECTRICALLY CONDUCTIVE COMPOSITIONS AND THEIR USE

by Cole Miller 1998

The present invention relates to a family of infrared radiating compositions having unique properties, and with a wide variety of utilitarian applications, along with the process of producing and using the same.

The compositions are electrically conductive, and when connected to appropriate electrical power sources, either alternating current (AC) or direct current (DC), convert electricity and produce electromagnetic oscillations falling within the infrared region of the electromagnetic spectrum. The radiation from the conversion of the consumed electrical energy, when intercepted by and falling upon objects of any nature, is converted into sensible heat, and thus warms by radiation. The particulate compositions and coatings themselves, at the same time, become hot to extremely hot, and by convection heat the air, gases, fluids and solids of any nature in the vicinity of the coatings, as well as heating by conduction the substrates on which the coatings are applied as well as the back supporting structures.

The formulation of electrically conductive coatings is well established in art and practice. In this prior art, a wide variety of free base metals, such as zinc, lead, nickel, aluminum, copper and a variety of alloys and the like; precious metals such as silver, gold, palladium and the like, metallic salts, alkaline earth metals, elemental carbon, such as carbon black or graphite, as well as metallic wires and carbon filament's have been used alone and in combination in finely divided form or as filaments, wire, rod roving and braids in film and sheet form; and incorporated in various concentrations in matrices which form thin and thick films, coatings, paints, adhesives, sealants and potting mastices. The processes for producing these electrically conductive coatings as well as their application in radiant, convective and conductive heating elements, in electrostatic discharge and in electrical conduction, is similarly well established in art and practice and covered by numerous U.S. and foreign patents. To cite one example, in U.S. Pat. No. 3099,587 Hunter discloses formulations for electrically conductive coatings to be applied to non-conductive surfaces, consisting of a mixture of C, Ag, and Fe in varying percentages incorporated in a thermosetting resin.

Similarly, the art and practice of heat-producing thermogenic coatings has been disclosed in British Patent 1,296,855 issued Nov, 22, 1972 to J.A. Saunders. This patent discloses an aqueous mixture of graphite and conductive carbon black in potassium silicate and lithium silicate-sodium silicate solutions along with appropriate wetting agents. The same pigment mix was shown to function in solvent-based coatings cast from a variety of thermosetting and thermoplastic resins. Applications have been made for a U.S. Pat, filed Apr, 13, 1970 (Ser. No 28,154).

However, the performance of coatings described in the literature leaves much to be desired. For reasons cited herein below the heat output is difficult to control, and heat producing coatings or paints show great variation in their day to day performance.
Metals in powder form oxides and other compounds on their surfaces.
These metallic oxides are non-conductors and impede the passage of electric current.
Additionally, all the metals have positive thermal coefficients of resistance, i.e., with increase in temperature their resistance increases, and their conductivity decreases. Thus, the dispersions of these materials frequently fail to provide the conductive stability required for successful commercial application. The cited

British Patent requires the use of a large expensive transformer to control the voltage when the paint is used for radiant heating in homes, thus adding greatly to the cost of installation. Last, but not least, the above mentioned precious metals are expensive, and the resulting costs of compositions made there from severely limit their areas of application.

Accordingly, this invention provides a electrically conductive particulate composition and an electrically conductive coating composition which contain a balanced mixture of conductive, resistive and stabilizing ingredients, thus reducing the inherently high dialectic resistance of coating vehicles employed therewith.

This invention also provides a device for radiant, conductive, or convective heating, or combinations of these heating modes, wherein the device comprises the substrate of this invention coated with either of the coating compositions of this invention, and at least two electrodes in contact with said compositions for the passage of electric current.

Further when the coating is cured, it forms an infrared radiating coating when an electric current is passed there through. This invention further provides a process of heating a solid, liquid, gas or combinations thereof by conduction, convection, radiation or combinations of these means, by applying an electrical potation between at least two of the electrodes contained in the devices of this invention.

This invention also provides a process for manufacturing a heating device by applying to a substrate a layer of uniform thickness. Also this invention provides a means for signaling, information transmission and status reporting by utilizing the electromagnetic oscillations of the infrared wave lengths generated; additionally, this invention provides a means of carrying electrical current and providing electrical continuity thereby, thus substituting for other more conventional electrical conduction devices, such as wires, cables, bus bars etc.

A process for signaling information transmission and status reporting involves applying an electrical potential between at least two of the electrodes contained in the devices of this invention to thereby generate infrared radiation, and the sensing this radiation. Infrared radiation sensors are well known in the art. The output from the sensor, usually in the form of an electrical signal, can be employed to activate, deactivate or control an electrical or mechanical device.

Electrically conductive coatings of this invention can be impervious to moisture and resistant to shock.

One feature of the present invention resides in the incorporation of a stabilizing carbon particle being flake like into an electrically conductive composition. Surprisingly, I have now found that the resistive flake like graphite in this formulation counterbalances the negative thermal coefficient of resistance of the graphite composition, so that the resulting formulation is neutral (i.e. a thermal coefficient of electrical conductivity of 1) and stable, (that is, the formulation shows substantially no increase or decrease in resistance with changes of temperature, thus a TCR of about zero). Moreover, the overall resistance in ohms per square of compositions of this invention does note change with changes in temperature, nor with varying voltage, nor change with time. Coating compositions, thus show no “start-up” amperage or current surges. In addition, they have been shown to be conductivity stable with time. Also composition of this invention emit infrared radiation with an emissivity close to that of a “black body” (0.968 to 0.988), thus converting the consumed electricity into radiant and convective heat with an efficiency 100% over that of resistive heating wires. Radiation efficiency of the formulations disclosed herein has been calculated to be 98 to 99% compared to metal-sheath infrared heaters having efficiencies of 56%, quartz-tubes of 62%, T-3 type and tungsten filament quartz lamps of 86%, and resistive wire and coils of 50%.

Further, radiant space heaters which are designed to cover large areas or warm people and objects in relatively large enclosed or open spaces, personal comfort heaters are designed for small space heating or conduction heating for individuals or a few objects. They are of low wattage output. This invention can be employed in the manufacture of heaters of this type, examples of which include; radiant heaters for incubators, for human and animal use, such as hospital beds for burn patients, premature infants, and poultry, chicks, pigs, etc., and for barnstall heaters for larger animals (horses, cattle), and zoo cages; incubation cabinets for bacterial cultures; as well as conduction heaters for underfoot mats, movable or fixed; thermal or “artic” clothing, and hot pads and heater blankets.

Other application include sauna room heaters; hot air heaters for and dryers; hair dryers; cooking and restaurant appliances, such as toasters, food warmers, griddles, electric frying pans, stoves and ovens, electric hot plates, grills and rotisseries and steam table warmers.

The infrared radiating exothermic compositions of this invention can be used as the source of radiant heat in all types of conveyor ovens, widely used in industry for drying, curing, baking, shrink packaging, etc.

The surfaces of pipelines and storage tanks can be painted directly or wrapped with the exothermic compositions of this invention impregnated into, or adhered to, a flexible tape or sheet carrier.

The availability of the exothermic paints to cover large areas evenly and to produce the necessary heat density required to melt snow and ice and prevent their formation, permits the economical and practical use of this material and formulation.

Since most of the exothermic coatings described herein are waterproof, and, in addition, can be covered or encased in waterproof insulating topcoats, they can be immersed in water without degradation or danger of electrical leakage or shock. They thus can serve as immersion heating elements with the special advantage of low wattage density extending over a large area. They are capable of heating large bodies of water without local boiling or “hot spots”, and without the need for special circulating pumps. The exothermic coatings may be painted on the sides of the retaining walls or on the bottoms of the water vessel; or, in the form of panels, attached to the walls, or suspended in the bodies of water, or laid on the floors of the vessels. Specific application include; swimming pool and aquarium heaters; animal watering through heaters; pond and lagoon heaters and drainage ditch heaters.

Exothermic coating formulations mounted on rigid boards or flexible carriers, operable from either line current or battery power, or from the engine’s alternator directly or through a power converter, can be used in a variety of forms to supply the required radiant heat for a particular application. This category may include under-engine or oil pan heaters, under-hood heaters, battery heaters, interior comfort heaters, and the like.

The build-up of static electricity in chemicals and plastics processing, in handling fine powders and dusts, in television receivers, in delicate electrical instruments rooms, in rugs and wall coverings, in hospital operating rooms, in paint factories, munitions plants and munitions and rocket propellant loading facilities, etc; during normal operations are very hazardous. The formulations of this invention may be employed, and indeed are preferred, instead of the anit-static coatings used presently, since they exhibit a stable ohmmage over the entire range of temperatures under which they operate. This class would therefore include anti-static coating paint, coated transfer film, coated sheeting, and coated floor tiles.

In the art and practice or working with an exothermic infrared generating coating system, all facets of the system requirements must be considered, and the properties balanced, taking into consideration all limitations of what-ever nature- physical, chemical or electrical. Thus, the binder must be mated with the pigment to produce a system having the desired characteristics. For any particular application, almost any binder with physical, chemical and electrical properties suited for that system can be utilized. Since the binder is an integral part of the system and numerous types of organic an inorganic, natural and synthetic, animal, vegetable, or mineral, aqueous or solvent, thermoplastic or thermosetting, rigid or flexible binder systems can be utilized in the application of these exothermic infrared emitting coatings, and almost limitless variety of types of coatings are possible, depending only on the end application of the product. From the available handbooks and published data, on skilled in the art can select an appropirate binder system.

The less severe the requirements to meet temperature and enviromental stress factors, the greater the number of suitable binders available for use. Many thermoplastic or thermosetting resin systems can be employed successfully if the maximum temperature demanded is limited to 250F.

As the temperature requirements increase, especially long-term aging without degradation at higher temperatures, the number of suitable candidate binder systems rapidly decreases. On the other hand, when a binder system with good high temperature resistance is called upon only to perform at temperatures well below its maximum capabilities, this “reserve” capability can usually be translated into or equated with very much higher reliability, longer life, and better aging characteristics at an expotential rate.

Those versed in the art of coatings and paints will readily be able to select, from the information given below, the large number of variations possible to meet the specific requirements for any application, or a general formula suitable for many applications.

Numerous binder systems can be employed, amongst which can be listed, by commonly accepted generic categories: acrylics, alkyds, cellulosics, epoxies, fluoro-plastics, ionomers, natural rubber, nylons, phenolics, polyamides, polybutadiene, polyesters, polymides, polypropylene, polyurethanes, silcone resins, and silicone rubber, styrene-butadiena; nitrile rubber, polysulphide rubber, vinly-ethyelene, polyvinyl acetate; silicates and polysilicates; hydraulic setting Portland cement, sodium aluminate and gypsum (plaster of Paris); glass compositions, including glass frits; ceramic and refractory compositions; and minerals, such as bentonite and the like. These organic and inorganic resins and polymers can be incorporated as solvent solutions or cast from heat melts, or they can be mad into aqueous emulsions or solutions.

This invention also contemplates the use of so-called “powdered lacquers” with the electrically conductive particulate blend. In this instance, the powdered lacquer is not generally considered to be part of the vehicle since powdered lacquers are frequently applied in a stream of air (the vehicle) or electrostatically. The powdered lacquer can be considered to be a binder, however, since it is capable of forming a film after being cured. Thus, this invention contemplates the use of liquid or solid binders with the electrically conductive particulate blend.

The limitations of the binder are physical, chemical, physico-chemical, electric, electronic, radiative and esthetic, as well as economic. By and large, the characteristics required encompass, but are not limited to, the following: thermal resistance, i.e. the ability to withstand exposure to the high degree of heat encountered in the application for prolonged periods desired of the application, e.g. 35,520 hours at 350F, without no significant degradation or physical changes which would affect the behavior and functioning and safety of the coating; good adhesion to the substrate to which it will be applied, and to the conducting electrodes; good cohesion and film-forming ability under pigment volume loading required to hold the concentration of pigment necessary for a particular application; a coefficient of thermal expansion which approximates that of the substrate so that the coating will not crack or delaminate from its substrate or applied electrodes; a low viscosity at a sufficiently high solids content to permit the incorporation of the pigment volume loading required for a particular application; a degree of film flexibility, after drying and cure, required by the application; no physical or chemical effect on the substrate to which it will be applied; ability of the film to withstand the physical and chemical and environmental stresses to which it will be subjected (e.g. vibration, shock, humidity, water, salt spray, solvents, acids, alkalies, temperature extremes, temperature cycling, sunlight (UV radiation), ozone, fungal and bacterial degradation, etc); capability of aging with time and use without no significant changes (breakdown) in these physical and chemical properties and without migration of the incorporated pigments; non-flammability or self-extinguishing characteristics; and with an inherent volumetric resisitivity sufficiently low so that the pigment can overcome this interface transitional resistance in establishing electrical continuity between the applied electrodes. All these aforementioned requirements can be fully met by this invention.

In view of these factors, it will be apparent that the proportions of the conductive particulate blend and vehicle in the coating composition of this invention, and the proportions of binder and solvent (when used), can vary over a wide range. It has been found that it is frequently easier and more practical to work with a “standard” formulation containing a fixed amount of the conductive particulate blend per volume of binder, dilute as required, and apply the necessary quantity of paint, i.e. number of grams of pigment per square inch of surface for each different type of binder system.