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PYROTECHNIC COMPOSITION CONTAINING
NICKEL AND ALUMINUM

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5 Claims

ABSTRACT OF THE DISCLOSURE

A pyrotechnic composition containing nickel and aluminum which may contain in addition magnesium, ferric oxide or bismuth, a pyrotechnic article made from the pyrotechnic composition and a method of preparing the pyrotechnic article by compaction of the appropriate metal powders or by rolling, swaging, drawing or plating to form composite configurations.

BACKGROUND OF THE INVENTION

This invention relates generally to pyrotechnic compositions, pyrotechnic articles and the methods for making them. More particularly, it relates to a composition containing nickel and aluminum and an article made from that composition by compressing the appropriate metal powders, by rolling, swaging, drawing or plating metal wires or strips.

Pyrotechnic compositions usually contain elements such that when they react after sufficient heat or activation energy is provided they will produce a strongly exothermic reaction. This large source of heat and light has many and diverse applications such for example, as demolition devices, emergency beacons or flares, fuses, detonators, separators, fuels and for welding and cutting metals.

Prior to this invention, the art has used the reaction of either palladium or platinum with aluminum to provide an excellent heat source, however this reaction suffers from the deficiency that it requires the use of such expensive metals as palladium and platinum.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to provide a pyrotechnic composition which can be made from readily available and inexpensive materials.

Another object of this invention is to provide a pyrotechnic article which effectively utilizes the pyrotechnic composition. A further object is to provide a method of preparing a pyrotechnic article.

Briefly, in accordance with one embodiment of this invention, these and other objects are attained by a composition containing aluminum with nickel. The composition may in addition contain magnesium, ferric oxide or bismuth. The pyrotechnic articles include a pellet made by compaction of the appropriate metal powders and a sheet, wire or strip formed by rolling, swaging, drawing or plating the metals.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following examples of suitable pyrotechnic formulations are given by way of illustration and are not to be considered as limiting the invention. The percentages given are by weight and the ranges of the particular compositions used are also included.

EXAMPLE 1

	Weight percent	Range percent
Nickel.....	68.5	40-80
Aluminum.....	31.5	60-20

EXAMPLE 2

	Weight percent	Range percent
Nickel.....	30.49	19.6-45.7
Aluminum.....	28.04	27.1-29.4
Fe ₂ O ₃	41.47	53.3-24.9

EXAMPLE 3

	Weight percent	Range percent
Nickel.....	68.5	80-51.4
Aluminum.....	20.4	20-23.6
Magnesium.....	11.1	0-25.0

EXAMPLE 4

	Weight percent	Range percent
Nickel.....	18.4	18.4-36.0
Aluminum.....	8.5	85-16.5
Magnesium.....	22.9	22.9-14.9
Fe ₂ O ₃	50.2	50.2-32.6

EXAMPLE 5

	Weight percent	Range percent
Nickel.....	10.2	10.2-17.8
Aluminum.....	4.7	4.7-8.1
Magnesium.....	12.6	12.6-11.0
Bismuth.....	72.5	72.5-63.1

The powder mixture of Example 1 is compacted into pellets and heated to approximately 660° C., the melting point of aluminum, whereupon a violent, although practically noiseless, exothermic reaction occurs producing molten NiAl and temperatures exceeding 1700° C. as measured by an optical pyrometer. The reaction is also gasless and once initiated will proceed without support or inclusion of oxygen. Further, since the reaction is initiated by heat alone and the mixture itself is relatively insensitive to shock, impact and vibration, pyrotechnic devices utilizing this mixture are perfectly safe for handling, fabrication and storage.

The composition of Example 1 may also exist in a composite strip formed by rolling sheet stock or powders or by plating either metal onto a base of the other metal. The composition further may be set forth in a wire by swaging and drawing the metals using either material as a core element and the other as a sheath around the core. A variation of this was provided by braiding the composite wire to produce components of added strength and large cross sectional areas with sufficient ductility.

Fe₂O₃ is added in Example 2 in order to accelerate the propagation of the exothermic reaction of the basic mixture of Example 1. The Fe₂O₃ addition does not change the initiation temperature. This composition is found to be very effective underwater where the reaction goes to completion once initiation occurs. The usual form of the mixture is in pellets or shapes compacted from the metal powders.

Another variation of this invention is the inclusion of magnesium in a mixture of nickel and aluminum, illustrated in Example 3. In this example, magnesium and additional aluminum are added as a eutectic mixture (37.5% Mg, 62.5% Al) to the mixture of nickel and aluminum and the resulting overall weight percentages are as expressed.

The actuation temperature for this mixture is approximately 650° C. and the reaction produces temperatures in excess of 2400° C.

A variation of Example 3 is the use of a non-eutectic mixture of magnesium and aluminum with the basic nickel and aluminum mixture. This combination is the most effective when an oxide such of Fe₂O₃, BeO, CuO or MnO is also included. For example, Fe₂O₃ is employed in Example 4. This combination of elements and oxide provides a much faster propagation rate of reaction and

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it is particularly effective for cutting devices. A further alternative is to add bismuth to the mixture of nickel, aluminum and magnesium as in Example 5 which has the advantage of a lower initiating temperature of about 480° C. The mechanism thought to be involved here is that magnesium reacts exothermically with bismuth thus providing enough heat to ignite the main charge of nickel and aluminum.

A pyrotechnic mixture can be ignited in various ways and once initiation occurs, the propagation velocity becomes a function of composition and density among other factors. For example, compressed powder configurations or pellets made from these mixtures can be ignited by placing them in contact with loose powder of the same composition and then igniting the powder by means of small heating elements, electric matches or conventional ordnance ignition systems. Ignition may also be provided by heating stoichiometric mixtures of either niobium or tantalum with copper oxide to about 400° C. These low ignition materials are particularly effective since only about 0.5 gm. of these materials will provide ignition within 0.5 to 2 seconds.

The pyrotechnic mixtures mentioned in the examples can be processed into many shapes and sizes utilizing a variety of fabrication techniques. One method, which can be employed, is to compact the powder into a pellet. In the actual tests, the powders have an average particle size of approximately 44 microns and were compressed at 40,000 p.s.i. into pellets having a density of about 3.7 gm./cc. However, the mixture can be used as a pyrotechnic in either the original powder form or in conjunction with other powder, liquid or semi-solid pyrotechnic materials. The powders may also be enclosed in plastic or metal containers which can be molded to any desired shape. But, in the use of powder mixtures, it is important to make sure that there is intimate contact between the various powders and this can be accomplished by initially compacting the powders into pellets and then fracturing the pellets into smaller particles.

Another fabrication procedure involves rolling of powder mixtures or laminate strips to form composite sheet material. Some of the mixtures can also be made into thin strips or fine wire by cold extrusion, swaging, drawing and rolling. Simple composite materials can be produced

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by electroplating; for example, nickel can be plated onto fine aluminum wire, foil, ribbon or powder. Another method of using the mixtures is to fill a honeycombed structure with the powders.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A pyrotechnic composition consisting of nickel, aluminum, magnesium and a metal oxide.
2. A pyrotechnic composition consisting of nickel, aluminum and 11.0 to 25.0 weight percent magnesium.
3. A pyrotechnic composition consisting of nickel, aluminum, and 24.9 to 53.3 weight percent metal oxide.
4. A pyrotechnic composition according to claim 3 wherein the metal oxide is ferric oxide.
5. A pyrotechnic composition consisting of nickel, aluminum, magnesium and bismuth.

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