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(72) Inventors:
• **Gil Buendia, Andres**
30500 Murcia (ES)
• **Soler Rodriguez, Enrique Dario**
30500 Murcia (ES)

(71) Applicant: **Real Federacion Espanola de Caza**
28039 Madrid (ES)

(74) Representative: **Isern-Jara, Nuria**
Avda. Diagonal 463 Bis 2°
08036 Barcelona (ES)

(54) **Chemical composition for manufacturing ammunition**

(57) The invention herein relates to a chemical composition for manufacturing ammunition comprising a plurality of alloying elements in the chemical composition selected from the group formed by zinc, tin and alumin-

ium. The invention herein further relates to the ammunition obtained from said chemical composition and to the use thereof for manufacturing lead-free ammunition.

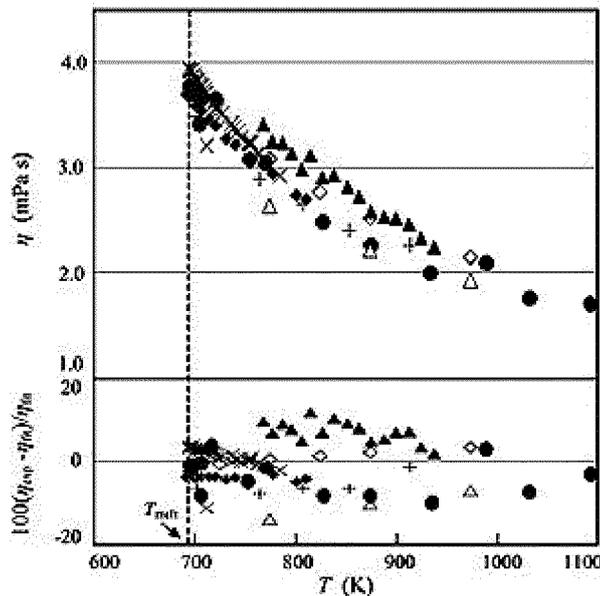


FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The invention herein relates to the field of materials for the production of ammunition, more specifically, lead-free ammunition for both hunting and target shooting, that are environmentally-friendly.

[0002] The invention herein relates to a chemical composition for manufacturing ammunition comprising a plurality of alloying elements in the chemical composition selected from the group formed by zinc, tin and aluminium.

[0003] The invention herein further relates to the ammunition obtained from said chemical composition and to the use thereof for manufacturing lead-free ammunition.

STATE OF THE ART

[0004] Both the market and the authorities require the products industry to be increasingly environmentally friendly, not only in its use phase and disposal by the end user, but throughout its value chain. There is an obligation for the industry to seek alternatives that are viable while using the best technologies available.

[0005] The main problem with lead is that it is a highly toxic heavy metal that affects the physiology of living organisms and to which functions that are essential to life are not attributed (Pain Dj, Cromie RI, Newth J, Brown Mj, Crutcher E, Hardman P, Hurst L, Mateo R, Meharg Aa, Moran Ac, Raab A, Taggart Ma and Green Re (2010). Potential hazard to human health from exposure to fragments of lead bullets and shot in the tissues of game animals. PLoS One 5:e10315).

[0006] It is from the industrial revolution and its intensive use for manufacturing different products when lead became a metal having ubiquitous characteristics, becoming a constituent of many biotic and abiotic components of the environment as its industrial application has been quite diverse, mainly being used for manufacturing batteries, water pipes, paints and as an antiknocking agent in fuels, becoming a source of poisoning for humans and pets and has been banned for some of these uses.

[0007] However, to date, the lead shot is the most frequently used ammunition for hunting and for target shooting. There are numerous products on the market that claim to be substitutes for lead shots, but thus far none has proven to be a viable product for the intended purpose, either for not meeting the requirements of end users (or other intrinsic qualities) or for not being a viable product from the perspective of medium or large scale production, or due to the price.

[0008] It is important to consider that when lead is bioavailable, it can penetrate into soil, water and sediment, and transfer from the abiotic components in the environment to the biotic components. This process depends on

climatic variables, such as the soil type and its chemical characteristics, as well as the water and sediment characteristics.

[0009] In addition, lead is not an essential metal for plants either and, in excessive amounts, can cause growth inhibition, a reduced rate of photosynthesis, alterations in mitosis and reduced water absorption. Depending on the mineral composition and chemical properties of the soil, the metal forms of lead may become bioavailable and be absorbed by the plant. By accumulating in plants, lead can be transferred to animals and to humans through the food chain. Rooney et al. (1999) in his study entitled "Distribution and phytoavailability of lead in a soil contaminated with lead shot. Water, Air and Soil Pollution 116:535-548" documented high levels of lead in forage plants for livestock and human consumption, correlated positively with soil contamination by lead ammunition.

[0010] The consumption of meat from hunted animals is another route of exposure to lead in humans, either by direct ingestion of ammunition or from invisible particles in the pectoral muscles or via the contaminated trail the ammunition leaves through the tissue. In 2010 Pain et al. found that the concentration of lead in meat from animals hunted with lead bullets or ammunition has a direct correlation with the amount of remaining ammunition or fragments thereof in the muscles, even having removed the visible fragments prior to cooking. Recently it was found that cooking game meat, in particular when preparing marinades, causes the lead from ammunition to be released into the meat, reaching levels exceeding those deemed acceptable by the regulations of the European Union (Mateo R, Rodriguez De La Cruz M, Vidal D, Reglero M Y Camarero P (2007) Transfer of lead from shot pellets to game meat during cooking. Science of the Total Environment 372:480-485).

[0011] Given all these environmental and public health problems, it is very necessary to find an alternative to lead in the composition of ammunition.

[0012] Therefore, if we focus on the standard pellet ammunition, we find that the most widely sold alternatives available to date are steel, tungsten and bismuth, which have the following characteristics:

- The steel shot is lighter and stronger than the lead shot and, therefore, the ballistic properties are significantly different. It does not show a deformation capacity and requires a greater charge of powder in the cartridges, requiring the use of special shotguns for this purpose.
- The Tungsten shot has a much higher pellet density than lead (19.3 g/cm³ vs 11.5 g/cm³) and is much more expensive, between 400-700% more than lead. In addition, there are insufficient stocks of tungsten to replace the current demand for pellets.
- The bismuth shot, while showing a similar pellet den-

sity to lead, is very fragile. There is also its high price to consider; between 400-500% more than lead.

[0013] The invention herein focuses on providing an alloy whose majority element is zinc, a metal whose advantages and benefits to society have been demonstrated beyond doubt. Despite being a transition metal zinc has a lower toxicity than lead. Zinc is a substance that is not classified, i.e., the Safety Data Sheet (endorsed by prestigious institutions) shows that Zinc is not included in the list of hazardous substances pursuant to Regulation (EC) No 1272/2008 [CLP/GHS], and neither it is included in the list of hazardous substances pursuant to Directives 67/548/EEC and 1994/45/EEC. This results in sufficient advantages in terms of safety, thereby making it suitable for use.

[0014] Zinc is an essential mineral and is important for many aspects of human health, being an essential trace element which is imperative for the body to function properly. Zinc plays a key role in the integrity of histones (DNA-binding proteins) and polymerases (enzymes responsible for the protein synthesis from DNA), therefore, it is vital for growth and tissue repair. It is also an integral part of important enzymes such as insulin or carboxylic anhydrase (enzyme responsible for the final elimination of carbon dioxide from the body).

[0015] All trace elements are toxic in excess, but zinc is the least toxic of all trace element and, therefore, the element selected by the inventors of the patent application herein to develop alloy, object of the invention.

[0016] Zinc is present throughout the earth's crust and in many foods such as sesame seeds, nuts, canned sardines, chicken breasts, peanuts, legumes, wholegrain bread, oysters, lobsters, etc.

[0017] To document the state of the art, the researchers of the invention herein wish to highlight some patent documents that are related to the solution of the same technical problem, object of the invention herein. It is thus seen that patent application registered under Publication No. GB2211920A, describes the development of composite pellets by zinc/aluminium or zinc/tin binary alloys, with possible additions of other metals such as copper, magnesium, silicon, alkali metals and alkaline earth metals. However, the problem or technical drawback with this invention is that the behaviour of these pellets does not meet the requirements of the end user because it does not deform due to the high hardness that zinc has with respect to lead, and may even fragment on impact with the piece and tear it apart due to shrapnel being generated. Proof of this is that this relates to a patent dating from 1988, and has not accepted by consumers in this market.

[0018] Another patent document is the Spanish patent filed under publication number ES2223305A1, which describes the manufacture of ecological ammunition comprising a metal matrix and reinforcing particles distributed therein. Said metal matrix is composed of different binary alloys, the reinforcing particles being wolfram or ferro-

wolfram. While the contribution of said material confers the product with density values similar to lead, from the perspective of production and price, with the technology that is available to date, the product becomes significantly more expensive.

[0019] Therefore, obtaining an optimal technical solution that provides lead-free ammunition and that maintains appropriate ballistic properties at competitive prices that may be borne by consumers is still necessary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] To complement the description and for a better understanding of the characteristics of the invention, the following figures are attached as an integral part of said description, in which, as a non-limiting illustration of the invention, the following is shown:

Figure 1.- Represents a diagram of the variation of viscosity with the variation in temperature, showing a non-Newtonian fluid flow behaviour of the molten zinc.

Figure 2.- Represents a diagram of the variation of the zinc behaviour showing a variation in density with respect to the temperature.

DETAILED DESCRIPTION OF THE INVENTION

[0021] For purposes of the invention herein, the term "ammunition" is understood to mean that which includes any type of ammunition that can be used in weapons for hunting or target shooting such as for example, pellets, bullets, buckshot, etc.

[0022] The invention herein has been developed in order to provide a chemical composition for manufacturing a metal matrix composed of a zinc (Zn), tin (Sn) and aluminium (Al) alloy.

[0023] An essential element of the present invention is that the metal matrix is composed of a tertiary zinc/tin/aluminium alloy comprising a range between 0.1-15% by weight of aluminium and a range between 0.1-15% by weight of tin, the remainder being zinc and the usual contaminants present in said metal, such as silicon and/or iron, such that the individual values of the percentages of the different components of the composition are such that the total composition never exceeds 100%.

[0024] In a particular embodiment of the alloy, adding other elements, such as bismuth (Bi), magnesium (Mg), silicon (Si), copper (Cu) and nickel (Ni) for some specific situations is considered, such as the manufacturing of extreme calibres or adjustments to the production process depending on whether the raindrop method, Blie-meister method or printing method etc. is used.

[0025] The invention herein also relates to the method for obtaining the matrix wherein the selection of elements that constitute the compound confers the material with a very efficient metallurgical behaviour from the perspec-

tive of production thereof, as the viscosity is significantly reduced and the fluidity is increased to a range of non-elevated temperature between 390°C and 500°C, this being a critical aspect in terms of the production method chosen from the perspective of production due to the rheological behaviour thereof, having a non-Newtonian fluid flow behaviour of the molten zinc, thereby varying the viscosity with the temperature, as can be seen in Figure 1.

[0026] Another important aspect for consideration is the behaviour of zinc showing a variation in density with respect to the temperature, as shown in Figure 2. The variation in the surface stress of the fluid with respect to the presence of the various metals forming part of the alloy, object of the invention herein, are also considered.

[0027] The invention herein also relates to the use of said matrix for manufacturing ammunition.

[0028] The present invention discloses a material formed by a matrix, which despite having a lower density to that of lead, achieves a behaviour similar to the latter, as in the case of pressure, penetration and dispersion (and it is observed that at distances of 30-35m, a dispersion around 80-85% is obtained) or even in some aspects, improved performance, for example, less recoil and higher acceleration such that at the same initial speed, about 410m/s (loading and pressure conditions) the target is reached at a greater speed with lead-free pellet than with the classic lead pellet.

[0029] The selection of the elements that constitute the matrix, enable the charge of powder in the cartridge to be similar to that of the lead pellet, which is why there is no need for the user to change the weapon (as with steel shot pellets). Therefore, cartridge manufacturers will not have to make any changes to their production equipment.

[0030] The selection of the elements that constitute the compound, make it possible for the latter to deform and not fragment to then generate shrapnel which tears the piece apart, therefore having similar behaviour to lead and different to other previously mentioned alternatives, which are not the intended alternatives for this type of ammunition. Thus, the selection of the elements that constitute the compound enable it to deform by absorbing the kinetic energy of the impact triggering the moving target to come to an instant stop, without passing through it or causing excessive bleeding thereof. This is a substantial technical advantage.

[0031] The selection of the elements that form the metal matrix the compound is composed of, also makes it possible to compensate the lack of density (compared with lead) with a small contribution of mass. In this manner, with an increase of approximately 0.5 mm in diameter, the effect of compensating the lower density is achieved and the previously discussed results in comparison with lead ammunition are therefore obtained. In this manner, the lead-free pellet with a 3.10mm intermediate calibre acquires similar behaviour to the classic calibre 7 lead shot. These results have been clearly demonstrated beyond doubt in the various tests that have

been conducted on mobile and fixed targets to determine the efficacy of the product.

[0032] The invention herein is characterised in that it is a material formed by a metal matrix for manufacturing lead-free ammunition, being a zinc-based ternary alloy that confers the product with equivalent ballistic characteristics relative to lead, and which confer an ideal metallurgical behaviour for production with traditional means of producing lead shots or other lead ammunition, with high levels of productive efficiency, i.e., typical high production yields of "highly capable processes", obtaining values of capability index of the process exceeding 1.66 (Cpk >1.66), and is, in addition, the minimal waste obtained (typical of any production process) easily assumed by the process by means of feedback thereto without preconditioning, causing no wastage or loss of quality of the target material. Based on the above, once this product has been recovered after use, it can be easily recycled without additional losses and without the need for pre-treatment or conditioning.

[0033] The invention herein is characterised by a mixture of elements which results in a material that does not require complex technical means or important alterations for processing than those already available for the manufacture of conventional lead ammunition.

[0034] The invention herein has the indisputable advantage that it is a mixture of elements which give rise to an ammunition for the manufacture of pellet cartridges, which does not require new equipment or modification of existing production processes.

[0035] The alloy described in the invention herein can alter the natural physical behaviour of zinc, likening it to that of lead, in physical properties such as the values for viscosity and surface stress.

[0036] The alloy described in the invention herein can further alter the natural behaviour of the combinations listed in the patents cited in the section of the prior art, likening it to that of lead.

[0037] It is therefore an object of the invention herein a chemical composition for manufacturing ammunition comprising a plurality of alloying elements in the chemical composition selected from the group formed by zinc, tin and aluminium.

[0038] According to another important aspect, the chemical composition for manufacturing the aforementioned ammunition comprises the following percentages by weight in respect of the total weight of the alloy, such that the individual values of the percentages of the different components of the composition are such that the total composition never exceeds 100%:

- between 0.1- 97% by weight of zinc,
- between 0.1-15% by weight of aluminium and,
- between 0.1-15% by weight of tin.

[0039] According to another aspect, the percentage of

zinc further comprises silicon and/or iron.

[0040] Additionally, the chemical composition for manufacturing ammunition comprises bismuth (Bi) in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

[0041] Additionally, the chemical composition for manufacturing ammunition comprises magnesium (Mg) in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

[0042] Additionally, the chemical composition for manufacturing ammunition comprises silicon (Si) in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

[0043] Additionally, the chemical composition for manufacturing ammunition comprises iron (Fe) in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

[0044] Additionally, the chemical composition for manufacturing ammunition comprises copper (Cu) in a proportion of 0.01 to 10% by weight in respect of the total weight of the alloy.

[0045] Additionally, the chemical composition for manufacturing ammunition comprises nickel (Ni) in a proportion of 0.01 to 10% by weight in respect of the total weight of the alloy.

[0046] According to a preferred embodiment, the chemical composition according to the invention herein comprises the following percentages by weight in respect of the total weight of the alloy, such that the individual values of the percentages of the different components of the composition are such that the total composition never exceeds 100%:

- between 0.1-97% by weight of zinc,
- between 0.01-5% by weight of bismuth,
- between 0.1-15% by weight of aluminium,
- between 0.1-15% by weight of tin.
- between 0.01-5% by weight of magnesium,
- between 0.01-5% by weight of silicon,
- between 0.01-10% by weight of copper,
- between 0.01-5% by weight of iron and,
- between 0.01-10% by weight of nickel.

[0047] According to another important aspect, the invention relates to the ammunition obtained from the aforementioned chemical composition.

[0048] According to another important aspect, the invention relates to the use of the aforementioned chemical composition for manufacturing lead-free ammunition. More specifically, it relates to the use of said ammunition

for hunting and target shooting.

Claims

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1. Chemical composition for manufacturing ammunition **characterised in that** it comprises a plurality of alloying elements in the composition selected from the group formed by zinc, tin and aluminium.

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2. Chemical composition for manufacturing ammunition according to claim 1 **characterised in that** it comprises the following percentages by weight in respect of the total weight of the alloy, such that the individual values of the percentages of the different components of the composition are such that the total composition never exceeds 100%:

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- between 0.1-97% by weight of zinc,
- between 0.1-15% by weight of aluminium and,
- between 0.1-15% by weight of tin.

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3. Chemical composition for manufacturing ammunition according to claim 2 **characterised in that** the percentage of zinc further comprises silicon and/or iron.

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4. Chemical composition for manufacturing ammunition according to any of the preceding claims **characterised in that** it comprises bismuth in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

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5. Chemical composition for manufacturing ammunition according to any of the claims 1 to 3 **characterised in that** it comprises magnesium in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

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6. Chemical composition for manufacturing ammunition according to any of the claims 1 to 3 **characterised in that** it comprises silicon in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

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7. Chemical composition for manufacturing ammunition according to any of the claims 1 to 3 **characterised in that** it comprises copper in a proportion of 0.01 to 10% by weight in respect of the total weight of the alloy.

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8. Chemical composition for manufacturing ammunition according to any of the claims 1 to 3 **characterised in that** it comprises iron in a proportion of 0.01 to 5% by weight in respect of the total weight of the alloy.

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9. Chemical composition for manufacturing ammuni-

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tion according to any of the claims 1 to 3 **characterised in that** it comprises nickel in a proportion of 0.01 to 10% by weight in respect of the total weight of the alloy.

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10. Chemical composition for manufacturing ammunition according to any of claim 1 **characterised in that** it comprises the following percentages by weight in respect of the total weight of the alloy, such that the individual values of the percentages of the different components of the composition are such that the total composition never exceeds 100%:

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- between 0.1-97% by weight of zinc,
- between 0.01-5% by weight of bismuth,
- between 0.1-15% by weight of aluminium,
- between 0.1-15% by weight of tin.
- between 0.01-5% by weight of magnesium,
- between 0.01-5% by weight of silicon,
- between 0.01-10% by weight of copper,
- between 0.01-5% by weight of iron and,
- between 0.01-10% by weight of nickel.

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11. Ammunition obtained from the chemical composition of any of the preceding claims.

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12. Use of the chemical composition of claims 1 to 10 for manufacturing lead-free ammunition.

13. Use of the ammunition according to claim 12 for hunting and target shooting.

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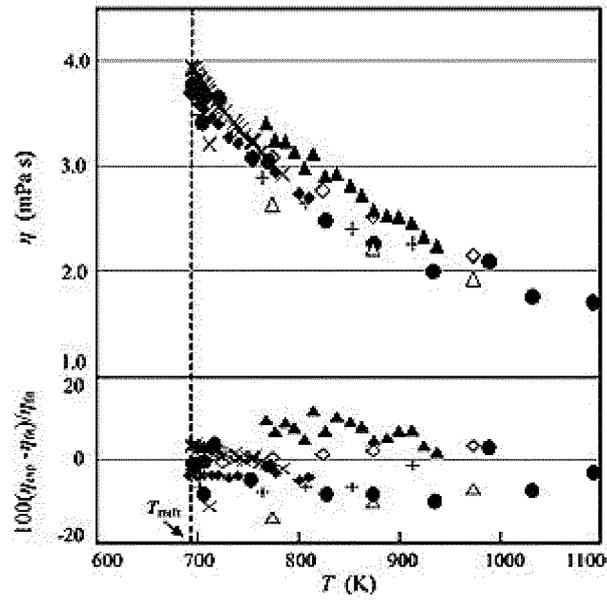


FIG. 1

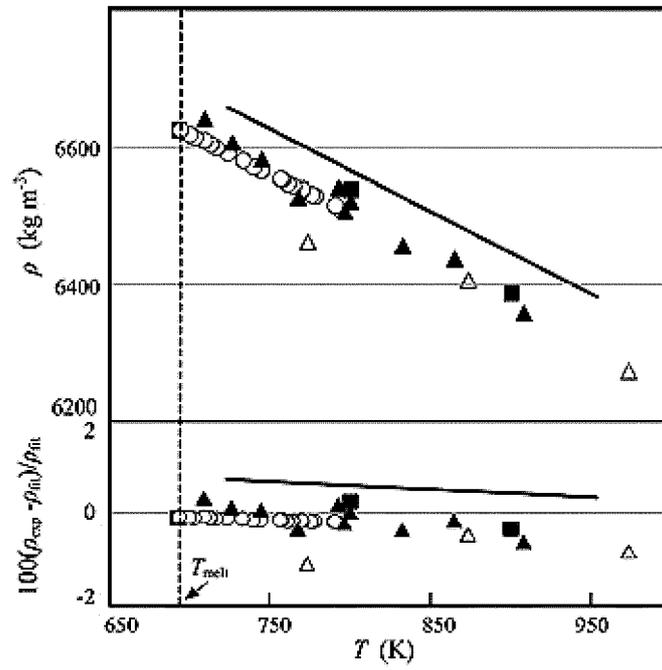


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
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Place of search The Hague		Date of completion of the search 8 May 2014	Examiner Giesen, Maarten
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