

[54] **NITROCELLULOSE PROPELLANT
CONTAINING DIFFUSED LINEAR
POLYESTER BURNING RATE DETERRENT**

[75] Inventor: **Dale F. Mellow**, Stanhope, N.J.

[73] Assignee: **Hercules Incorporated**, Wilmington,
Del.

[22] Filed: **Sept. 3, 1971**

[21] Appl. No.: **177,813**

[52] U.S. Cl. **149/11, 149/10, 149/96,**
149/98, 149/100, 149/94, 149/95

[51] Int. Cl. **C06b 19/02**

[58] Field of Search **149/10, 11, 19, 96,**
149/97, 98, 99, 100, 94, 95

[56] **References Cited**

UNITED STATES PATENTS

3,108,916 10/1963 Coffee et al. 149/11

Primary Examiner—Carl D. Quarforth

Assistant Examiner—P. A. Nelson

Attorney—S. Grant Stewart et al.

[57]

ABSTRACT

Manufacture of burning rate deterrent coated propellants by contacting a nitrocellulose smokeless powder, at an elevated temperature, with a defined linear polyester of a new class of burning rate deterrents, which wets, and diffuses into the smokeless powder at the elevated temperature level, as a plasticizer therefor, but is substantially non-migrating within the smokeless powder at lower temperatures; effecting the contacting step under conditions causing the polyester to coat and penetrate the smokeless powder to form the coated propellant; and then reducing the temperature of the resulting deterrent coated propellant to the lower temperature above described.

Also provided, are nitrocellulose smokeless powder propellants having as a burning rate deterrent, the defined polyester coating diffused by its own plasticizing action into the propellant to form a resulting burning rate gradient therefor.

11 Claims, No Drawings

NITROCELLULOSE PROPELLANT CONTAINING DIFFUSED LINEAR POLYESTER BURNING RATE DETERRENT

This invention relates to improved progressive-burning smokeless powder propellants, and to their manufacture. In one aspect this invention relates to a process, utilizing a new class of coating materials, as burning rate deterrents, for the manufacture of progressive burning smokeless powder propellants having improved burning rate gradient and ballistics properties. Other aspects will be apparent in light of the accompanying disclosure, and the appended claims.

It has been general practice in the propellant art to regulate burning rate of propellants so as to produce high projectile velocities without incurring unduly high chamber pressures, by coating the propellant grains with a deterrent material which will retard the initial burning rate of the grains. The practice has been particularly applied to smokeless powder propellants. Well known procedures for coating propellants with burning rate deterrent materials are set forth in U.S. Pat. Nos. 2,147,698, 2,179,330, 2,198,746, and 2,187,866.

The deterrent coating materials utilized have been of two types, based on their solubility in the propellant material, viz. the soluble, or plasticizer type, and the insoluble, or barrier type. The soluble, or plasticizer type, deterrent coating, due to its ability to plasticize the propellant material penetrates the propellant grain so that as the powder burns, the successively exposed surfaces contain gradually less and less of the deterrent material thus causing the combustion of the grain to proceed with increased speed along a substantially uniform burning rate gradient. However, although the plasticizer type deterrent coating initially produces the desired burning rate gradient for requisite progressive burning, those materials, during propellant storage, continue to migrate throughout the propellant grain and, after a period of time, they reach equilibrium concentration throughout the grain and hence fail to provide for the requisite burning rate gradient. The barrier, or non-plasticizer type, does not penetrate the propellant material and, although it does not migrate into the propellant during storage, it nevertheless fails to provide the progressivity of burning required for many applications. Various means have been proposed for dilution of the barrier type deterrents with materials soluble in the propellant material to afford some degree of penetration and hence burning rate gradient, but they have been disadvantageous in numerous applications, particularly when applied to the manufacture of small arms powders.

My invention is based on my discovery of a class of materials which function as burning rate deterrents for smokeless powder propellants, to provide broad uniform burning rate gradients without appreciable migration of the deterrent material into the propellant particles during storage; and hence provide propellants having improved burning rate gradient, and ballistics, stability.

In accordance with the invention a process is provided for the manufacture of burning rate deterrent coated propellants having improved burning rate gradient and ballistics properties, which comprises contacting a nitrocellulose smokeless powder, at an elevated temperature, with a linear polyester which is compatible with said nitrocellulose, has a weight average mo-

lecular weight of from about 1,500 to 30,000 and a melting point not exceeding about 190°F., which wets and diffuses into said smokeless powder at said elevated temperature as a plasticizer therefor but is substantially non-migrating within said smokeless powder at lower temperatures; effecting said contacting under conditions causing said polyester to coat, and penetrate, said smokeless powder to form said coated propellant; and reducing the temperature of the resulting coated propellant to a lower temperature above described.

The invention further provides nitrocellulose smokeless powder propellants having a linear polyester as a burning rate deterrent coating and diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 30,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

The invention, in preferred practice, is directed to smokeless powder propellants, and their manufacture, for small arms, and cannon, and to the deterrent treatment of smokeless powders for caseless ammunition charges and other applications, including cartridge actuated, and numerous other, industrial and military propellant devices.

Exemplary linear polyester burning rate deterrent materials utilized in practice in the invention are those formed from dihydric alcohol components such as ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol and neopentyl glycol, and dibasic acid components such as adipic acid, azelaic acid, phthalic acid, and sebacic acid. Now preferred, are those polyester deterrent materials having a weight average molecular weight within the range of 1,500 - 20,000 as further illustrated herein. As a consequence of being compatible with the nitrocellulose in the smokeless powder propellant, the polyester deterrent plasticizes the smokeless powder particle surfaces and remains in the substantially non-migrating state of diffusion, without rendering the propellant surfaces sticky or otherwise separating from the powder particles.

When referring herein to nitrocellulose smokeless powders, it is meant single, double, and triple based smokeless powders well known in the art—such as illustrated in U.S. Pat. No. 3,235,425.

Generally, the smokeless powder-polyester deterrent contacting, or coating, step is carried out at a temperature within the range of 150°- 212°F. for a period of from 1 to 200 minutes, utilizing from 0.5 to 10 weight percent of the polyester deterrent material, based on the weight of the uncoated smokeless powder.

The smokeless powder-polyester coating step is advantageously carried out in the presence of water, the proportions of water being variable over a broad range. I have found that in accordance with procedure described hereinabove utilizing water as a vehicle in an aqueous slurry coating system such as that illustrated with reference to Example 2, the weight ratio of water to smokeless powder in the aqueous slurry can be in the range of from 1:1 to 20:1, more often at least as high as about 4:1. On the other hand, a lesser proportion of water can be advantageously utilized, generally without formation of an aqueous slurry as illustrated with reference to Example 1. In that embodiment, a weight ratio

of water to the smokeless powder in the coating system within the range of from about 0.05:1 to about 1:1, but more often not exceeding about 0.2:1, is utilized. Thus, although the amount of water utilized in these embodiments, is generally within the range of from about 0.05:1 to 20:1, the higher proportions within that range are applicable to aqueous slurry coating systems.

I have found that it is advantageous to introduce the polyester deterrent material into the coating step, when dissolved in a solvent-diluent therefor, which is not a solvent for the nitrocellulose, to lower viscosity and thereby facilitate uniform distribution of the polyester material throughout the mass of smokeless powder. In those embodiments carried out in the presence of water, the solvent-diluent for the deterrent is also characterized by low water solubility i.e., it is substantially water insoluble. Methylene chloride is a now preferred solvent diluent; and other solvent diluents advantageously utilized include benzene, diethyl ether and n-butanol. The solvent-diluent generally has a boiling point not exceeding about 125°C. and is sufficiently volatile that it can be readily evaporated from the coating system. In other embodiments utilizing a diluent for the polyester to be introduced into the coating system, the deterrent is introduced into the system as an aqueous emulsion, as an aqueous homogenized suspension, or in the case of a non-aqueous system is dissolved in a suitable volatile non-aqueous solvent for the polyester, which is a non-solvent for nitrocellulose.

In accordance with one embodiment, a burning rate deterrent coated propellant of the invention is prepared by placing dry granular smokeless powder, to be coated, in a mixing vessel equipped with agitation means, followed, optionally, by addition of water in an amount up to about 40 weight percent of the dry smokeless powder. From 0.5 to 10 weight percent of the polyester deterrent coating material, based on the uncoated smokeless powder, is then introduced into admixture with the smokeless powder and water if present, and is often advantageously dissolved in a suitable diluent-solvent, which is not a solvent for the nitrocellulose in the smokeless powder, such as in methylene chloride in about equal weight proportions. The mixture vessel is then closed and the powder-polyester admixture is heated under constant agitation, generally by tumbling action, to 150° - 212°F. and maintained at that temperature for a period of from about 1 to 200 minutes.

At the end of the coating period, and with continued heating, the vessel, when methylene chloride or other volatile solvent-diluent for the deterrent material, and/or water is present, is opened and agitation is resumed to permit evaporation of the water and/or diluent, and drying of the resulting coated product until it becomes free flowing, at which time heating is terminated for recovery of the resulting dried coated propellant product at ambient temperature for storage.

In accordance with another embodiment of preparation of a deterrent coated propellant of the invention, granular smokeless powder, to be coated, is slurried in a mix tank with water in a water: smokeless powder weight ratio above described, more often from about 4:1 to 20:1, and the resulting slurry is maintained under agitation conditions while adding the deterrent coating material thereto in an amount of from about 0.5 to 10 weight percent based on the uncoated smokeless powder,

the latter optionally dissolved in a suitable diluent, such as methylene chloride as above described.

The resulting water slurry of deterrent coating material and propellant powder is then heated during continued agitation to 150° - 212°F. and maintained at that temperature level for a period of from 1 to 200 minutes to accomplish the required penetration.

At the end of the coating period the temperature of the water slurry of coated propellant product is reduced to below the storage temperature level, generally below 150°F., and the coated propellant product is removed from the slurry and air dried to form free flowing coated propellant.

In accordance with conventional procedure, the dry coated propellant product can be glazed, cleaned, and blended, when necessary, to provide the requisite ballistics.

EXAMPLE 1

A granular double base smokeless powder having an average grain size of 0.65 inch (diameter) $\times$ 0.011 inch (length) was coated with a linear polyester having a weight average molecular weight of about 6,600, as a burning rate deterrent material of the invention.

Another portion of the same granular smokeless powder was similarly coated with ethyl centralite, a well known plasticizer type burning rate deterrent for propellants, to provide a "control" propellant for comparative purposes.

The formulation of the double base granular smokeless powder to be coated, and the burning rate deterrent coating material utilized, are set forth in the following summary:

Granular Smokeless Powder		Weight Percent
Component		
Nitroglycerin		20.0
Nitrocellulose		77.75
Diphenylamine		0.75
Barium Nitrate		1.50

Polyester		Weight Percent	"Control"
Component			Ethyl Centralite
Neopentyl Glycol		49.9	
Adipic Acid		34.9	
Palmitic Acid		15.0	
Stearic-Oleic Acid		0.3	

In carrying out the procedure for coating the smokeless powder with the polyester burning rate deterrent, 10 pounds of the granular smokeless powder was placed in the barrel of a jacketed tumbler vessel, together with about 2 pounds of water; and 2 weight percent of the polyester deterrent material, based on the weight of the uncoated smokeless powder, was then introduced into the smokeless powder-water admixture, as a 50 weight percent solution in methylene chloride as a diluent therefor. The methylene chloride solvent is not a solvent for the nitrocellulose.

The barrel of the tumbler vessel was then closed, tumbling action was initiated, and heating fluid was circulated through the barrel jacket to increase the temperature of the smokeless powder/water/polyester admixture to 200°F. The tumbling was then continued at 200°F. for 90 minutes during which time coating action was complete to provide resulting coated propellant product. At the end of the 90 minute period, the tumbling was terminated, the barrel was opened, and tumbling was resumed at the coating temperature level to

permit evaporation of the water and methylene chloride to provide dry free flowing coated propellant product. The tumbling action, and circulation of heating fluid through the jacket, were then terminated, and the coated propellant product was then permitted to cool to ambient temperature.

The above procedure was utilized in preparation of the granular double base smokeless powder-ethyl centralite "control" propellant, except that the ethyl centralite was applied without a diluent therefor.

A series of 10 of each of two separate portions of each coated propellant product was loaded after preparation as shotgun cartridge components, and each series of cartridges was fired, one series of each coated propellant being fired promptly after loading and the other after an extended storage period. Each coated propellant (product and "control") contained 1.96 weight percent of the deterrent material. Data summarizing the firing tests are as follows:

		Firing data			
		Before storage ²		After storage at 140° F., 6 weeks	
Burning rate deterrent	Shotgun	Average muzzle velocity, f./s. ¹	Average maximum chamber pressure, p.s.i.	Average muzzle velocity, f./s.	Average maximum chamber pressure, p.s.i.
The polyester	12 gauge, 3"-----	1,221	11,600	1,201	11,300
Ethyl centralite	do-----	1,299	12,200	1,345	15,700
					Change in pressure, p.s.i.
					-300
					+3,500

¹ F./s., throughout the specification, equals feet per second.

² Before storage, herein, means within a 10-day period following preparation of the coated propellant.

The above data demonstrate substantially no penetration of the polyester deterrent material into the smokeless powder grains during storage, as evidenced by an actual decrease of 300 psi in average maximum chamber pressure, after storage. On the other hand, the data demonstrate ethyl centralite, a well known plasticizer type burning rate deterrent for propellants, to have penetrated the smokeless powder grains during preparation, comparable to that of the polyester deterrent, but to have seriously migrated into the smokeless powder grains, during storage, to impair the original burning rate gradient with a resulting increase in average maximum chamber pressure of 3,500 psi.

The data demonstrate diffusion of the polyester deterrent into the smokeless powder grains under coating temperature conditions, but substantially no migration at storage temperature levels, generally 150°F. or less, to be thereby substantially non-migrating during storage and provide for stable burning rate gradient and ballistics over prolonged periods.

EXAMPLE 2

One hundred grams of a double base smokeless powder propellant, having an average grain size of 0.038 inch (diameter) × 0.013 inch (length) was coated with a linear polyester burning rate deterrent material of the invention, having a weight average molecular weight of about 16,000. The granular smokeless powder and burning rate deterrent material are summarized as follows:

Granular Smokeless Powder	
Component	Weight Percent
Nitroglycerin	15.0
Nitrocellulose	84.15
Diphenylamine	0.85

The Polyester Burning Rate Deterrent

Component	Weight Percent
Ethylene Glycol	29.8
Sebacic Acid	65.4
Adipic Acid	1.5
C ₁₁ -C ₁₂ Dibasic Fatty Acids	2.0
Unaccounted For	1.3

In carrying out the procedure, a suspension of the granular smokeless powder in 670 grams of water was formed in a mixing tank, equipped with agitation means. 2 percent of the deterrent coating material, based on the weight of the uncoated smokeless powder, was then added to the smokeless powder/water suspension as a 50 weight percent solution in methylene chloride, under agitation conditions. After addition of the deterrent material to the smokeless powder/water suspension, the suspension was heated to 85° - 90°C. under continued agitation, after which the agitation was continued, and the temperature maintained at 85°

- 90°C. for an additional period of 30 minutes. At the end of the 30 minute period, coating of the smokeless powder grains was complete to provide resulting burning rate deterrent propellant product of the invention; and the coated propellant product was then recovered from the suspension and air dried. Penetration of the polyester deterrent material into the smokeless powder grain provided for the required ballistic properties, and the coated propellant product was free flowing with substantially no migration of the deterrent over prolonged storage periods to thereby exhibit burning rate gradient and ballistics, of improved stability.

EXAMPLE 3

The procedure of Example 1 was repeated except that preparation of the ethyl centralite formulation was omitted, the proportion of the polyester deterrent coating material utilized was 4.5 percent (based on the weight of the uncoated granular smokeless powder) the coated propellant product was fired in each instance as a component of a rifle cartridge, and the formulation of the smokeless powder to be coated was as follows:

Granular Smokeless Powder

Component	Weight Percent
Nitroglycerin	10
Nitrocellulose	88.25
Diphenylamine	0.75
Potassium Sulfate	1.0

The coated propellant product contained 4.3 weight percent of the polyester deterrent. These tests are further summarized as follows:

Burning Rate deterrent	Gun	Firing Data			
		Before Storage	After Storage at 140°F., 6 weeks		
		Average muzzle velocity f/s	Average maximum chamber pressure psi	Average muzzle velocity f/s	Average maximum chamber pressure psi
The Polyester of Ex. 1	Center-fire Rifle 5.56 mm	3172	49,000	3237	49,500

The data demonstrate an increase in average maximum chamber pressure of only 500 psi, a 1 percent increase, after 6 week storage period, as compared with an increase of 10,500 psi, a 24 percent increase, observed for the dibutylphthalate formulation of Example 6; and hence the marked stability of burning rate deterrent gradient over prolonged storage periods, provided in accordance with the invention.

EXAMPLE 4

The procedure of Example 1 was repeated utilizing the same double base granular smokeless powder, except that the deterrent coating material was a polyester deterrent of the invention having a weight average molecular weight of about 1,600, and preparation of the ethyl centralite formulation was omitted. The following summarizes the tests:

Burning rate deterrent	Shotgun	Firing data			
		Before storage		After storage at 140° F., 6 weeks	
		Average muzzle velocity, f./s.	Average maximum chamber pressure, p.s.i.	Average muzzle velocity, f./s.	Average maximum chamber pressure, p.s.i.
The polyester	12 gauge, 3"	1,204	11,300	1,226	11,900

¹ See the following table:

Component:	Weight percent
Ethylene glycol.....	16.1
Orthophthalic acid.....	42.0
n-Octanol.....	13.4
n-Decanol.....	18.7
Adipic acid.....	9.7
Sebacic acid.....	0.1

The data demonstrate the improved stability of burning rate gradient accomplished in practice of the invention, as shown by an increase in average chamber pressure after storage, of only 600 psi, a 5.3 percent increase.

EXAMPLE 5

The procedure of Example 1 was repeated utilizing the same double base granular smokeless powder, except that the deterrent coating material of the invention was a polyester having a weight average molecular weight of about 4,400, and preparation of an ethyl centralite formulation was omitted. The summarizing data are as follow:

Burning Rate Deterrent	Firing Data			
	Before Storage	After Storage at 140°F., 6 weeks		
	Average muzzle velocity f/s	Average maximum chamber pressure psi	Average Muzzle Velocity, f/s	Average Maximum Chamber Pressure, psi
15 The Polyester	1239	11,800	1254	12,100
Component	Weight Percent			
Ethylene Glycol	37.3			
Adipic Acid	41.4			
n-Decanoic Acid	0.2			
Lauric Acid	2.6			
Myristic Acid	3.4			
Palmitic Acid	7.1			
Stearic-Oleic Acid	8.1			

As in the preceding examples, the above data demonstrate an increase in average chamber pressure of 300 psi, a 2.6 percent increase, thus again demonstrating the stable burning rate gradients accomplished in practice of the invention.

EXAMPLE 6

The following data illustrate smokeless powder propellants having well known burning rate deterrent materials of the soluble, or plasticizer type, and for comparative purposes, a burning rate deterrent coated propellant of the invention described hereinabove with reference to Example 3.

			Firing data				
Smokeless powder component	Deterrent coating	Gun	Before storage		After storage at 140° F., 6 weeks		Percent change in ballistics after storage
			Average muzzle velocity, f./s.	Average maximum chamber pressure, p.s.i.	Average muzzle velocity, f./s.	Average maximum chamber pressure, p.s.i.	
Double base ¹	The polyester of Examples 1 and 3.....	5.56 mm. centerfire rifle...	3,172	49,000	3,237	49,500	1
Do. ²	Dibutylphthalate.....	do.....	3,163	44,600	3,174	55,100	23.6
Single base ³	DNT.....	.30-06 centerfire rifle.....	2,711	45,000	2,866	55,200	22.7
Double base ⁴	Ethyl centralite.....	12 gauge, 3''.....	1,229	12,200	1,345	15,700	28.7

The footnotes are:

The footnotes 1-4:

Footnote	Weight percent					Weight percent
	Nitro-glycerin	Nitro-cellulose	Diphen-ylamine	Ba(NO ₃) ₂	K ₂ SO ₄	
(1)	9.6	84.4	0.72			Deterrent coating
(2)	10.0	83.0	0.75		0.96	The polyester of Example 3
(3)		92.75	0.75			Dibutylphthalate
(4)	19.6	76.25	0.74	1.46	0.50	DNT
						Ethylcentralite

The above demonstrate substantially constant ballistics obtained in practice of the invention as compared with increase in average maximum chamber pressure of from 22.7 percent (DNT) to 28.7 percent (ethyl centralite) in the prior art compositions above.

The process embodiment of the invention utilizing an aqueous slurry type coating step is advantageously applied to water cut smokeless powder, inasmuch as it eliminates the need for removal of the water and residual solvent from the smokeless powder, and air drying, prior to the coating step. The residual solvent-wet smokeless powder, still containing from 5 to 20 parts solvent per 100 parts of smokeless powder, generally a mixture of ethyl alcohol and acetone in about equal volume proportions, is directly slurried with the water for the coating step, under which conditions the warm water due particularly to its large volume, promptly extracts the residual solvent from the smokeless powder to eliminate the presence of that solvent during the coating step.

The invention provides for the active control of the penetration of the burning rate deterrent to accomplish a stable burning rate gradient. Thus, the diffusion of the burning rate deterrent into the propellant, and hence its plasticizing action, provides for a degree of plasticization which increases with increase in each of time, temperature, and amount of coating material in the coating system; and the penetration accomplished is preserved under storage conditions, and until use, due to the non-migration of the burning rate deterrent within the grains. Thus by correlating temperature, time, and amount of the deterrent material in the coating system, a combination of coating conditions can be readily determined for accomplishing any predetermined degree of penetration, and for then locking in the deterrent to secure the resulting burning rate gradient for subsequent use.

As will be evident to those skilled in the art, various modifications can be made or followed, in light of the foregoing disclosure and discussion, without departing from the spirit or scope of the disclosure or from the scope of the claims.

What I claim and desire to protect by Letters Patent is:

1. A nitrocellulose smokeless powder propellant having a linear polyester as a burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 30,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

2. A smokeless powder propellant of claim 1, wherein said burning rate deterrent coating is a linear polyester formed from a dihydric alcohol and a dibasic acid.

3. A smokeless powder propellant of claim 2 wherein said dihydric alcohol is selected from the group consisting of ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol and neopentyl glycol, and said dibasic acid is selected from the group consisting of adipic acid, azelaic acid, phthalic acid, and sebacic acid.

4. A smokeless powder propellant product of claim 2 containing said polyester in an amount of from 0.5 to

10 weight percent, based on the weight of said smokeless powder when uncoated.

5. A smokeless powder propellant product of claim 4 wherein the average molecular weight of said polyester is within the range of from 1,500 to 20,000.

6. A nitrocellulose smokeless powder propellant having an ethylene glycol-sebacic acid resin as a linear polyester burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor, and said smokeless powder propellant containing said polyester in an amount of from 0.5 to 10 weight percent based on the weight of said smokeless powder when uncoated; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 20,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

7. A nitrocellulose smokeless powder propellant having an ethylene glycol-adipic acid resin as a linear polyester burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor, and said smokeless powder propellant containing said polyester in an amount of from 0.5 to 10 weight percent based on the weight of said smokeless powder when uncoated; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 20,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

8. A nitrocellulose smokeless powder propellant having an ethylene glycol-phthalic acid resin as a linear polyester burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor, and said smokeless powder propellant containing said polyester in an amount of from 0.5 to 10 weight percent based on the weight of said smokeless powder when uncoated; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 20,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

9. A nitrocellulose smokeless powder propellant having a neopentyl glycol-adipic acid resin as a linear polyester burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor, and said smokeless powder propellant containing said polyester in an amount of from 0.5 to 10 weight percent based on the weight of said smokeless powder when uncoated; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 20,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

10. A single base nitrocellulose smokeless powder propellant having a linear polyester as a burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate gradient therefor, and said smokeless powder propellant containing said polyester in an amount of from 0.5

11

to 10 weight percent based on the weight of said smokeless powder when coated; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 20,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder at temperatures not exceeding about 150°F.

11. A double base nitrocellulose smokeless powder propellant having a linear polyester as a burning rate deterrent coating diffused by its own plasticizing action into said propellant to form a resulting burning rate

12

gradient therefor, and said smokeless powder propellant containing said polyester in an amount of from 0.5 to 10 weight percent based on the weight of said smokeless powder when uncoated; said polyester being compatible with said nitrocellulose, having a weight average molecular weight of from 1,500 to 20,000, a melting point not exceeding 190°F., and being substantially non-migrating within said smokeless powder within temperatures not exceeding about 150°F.

* * * * *

15

20

25

30

35

40

45

50

55

60

65