

PVB-BASED STAR COMPOSITIONS

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A rejected patent application, number DE 4343725 A1, made in December 1993 by Franz Drexler and Hans Diesner of Pyrotechnik Siberhuetten Gmbh, describes the benefits of using PVB as a binder in pyrotechnic compositions. The advantages that they list include:

- It is a fine-grained free-flowing powder with a low bulk density
- Its solution in alcohol has good adhesive properties and a short drying time
- It favourably affects the burning characteristics
- In colour formulations it gives a high luminosity, coupled with high colour intensity
- Its decomposition products are non-toxic

They claim that it is a good binder in amounts from 0.2% to 5.0% and that stars made with it are highly resistant to the physical stresses of lift and burst charges.

This information seems to have been largely unknown or ignored—in the pyrotechnic community until quite recently. My first introduction to PVB as a possible constituent in pyrotechnic compositions came via the research that Richard Harrison and I were making into the crackle phenomenon, as reported in the September 2015 issue of AFN. Once its name came up, we began to hear of rumours that PVB was being used in both China and Malta, so I decided to try it out in a range of star compositions.

It quickly became apparent that PVB, in addition to its properties as a binder, is an effective organic fuel, so my first compositions, listed in Table 1, use it in both roles. They, like all the other formulations described in this article, should all be dampened with undiluted alcohol and can be cut, pumped or rolled.

	Red	Orange	Green	Yellow
Potassium perchlorate	27	53	19	47
Strontium nitrate	27			
Barium nitrate			48	
Strontium carbonate	12			
Barium carbonate		2		
Calcium carbonate		14		
Magnalium, 250#	17	14	15	29
Parlon	14	14	14	7
Cryolite		2		15
PVB	3	3	2	2

Table 1. Basic Colours

All these are bright-burning, easy to ignite and show a good colour. The yellow, with its high pro-

portion of magnalium, is particularly bright and burns fiercely, with a tendency to jet. The orange star is adjusted to my taste in colour; if you prefer a different shade, you might want to alter the relative proportions of calcium carbonate and cryolite.

The compositions listed in Table 2 are reasonable, but not particularly exceptional. The blue is one—based on a Chinese formulation—that was suggested by Tom Schroeder; it gives a reasonable colour, provided the stars are made fairly small. So far, I haven't had a great deal of success with my own trials of PVB-based blue stars. The bright-burning characteristic of PVB, which is an advantage for other colours, seems to be detrimental in blue compositions and I have not, so far, been able to create stars that show anything other than a somewhat washed-out shade.

	Blue	Purple
Potassium perchlorate	60	56
Sulphur	19	
Copper powder	8	
Copper oxide		14
Strontium carbonate		7
Parlon	8	14
Magnalium, 230#		7
Phenolic resin	4	
PVB	1	2

Table 2. Blue and Purple

The patent application makes a veiled suggestion that PVB can promote vibrational burning, so I also experimented with its use in strobe compositions. The formulation of Table 3 strobos well and needs little in the way of priming, as it ignites easily. It burns moderately slowly and it is probably best to make stars that are no more than ¼ inch (6 mm) in diameter.

Barium Nitrate	52
Potassium Nitrate	4
Sulphur	26
Magnalium 250#	14
PVB	4

Table 3. White Strobe

The formulation in Table 4 was sent to me by David Goodfellow. It is a variation on the Jopetes Spanish silver kamuro, where the dextrin is replaced by 2% PVB. I have adjusted the proportions to be true percentages.

Potassium Nitrate	62.7
Charcoal, airfloat	6.3
Sulphur	14.5
Titanium, 60#	14.5
Dextrin	2.0

Table 4. Silver Kamuro

So far, I have not thoroughly investigated the effect of PVB on glitter formulations but initial trials on Winokur's No. 16 suggest that using PVB as the binder gives a slightly sparser effect, but with a longer delay and brighter flashes. The formulation in Table 5, which I call 'Snowball', isn't a true glitter, but gives an effect that I find very pleasing. It also works well, but with a slightly different spark quality, if you use fine atomised aluminium instead of flake.

Potassium nitrate	39
Barium nitrate	18
Sulphur	10
Charcoal	10
Antimony trisulphide	11
Aluminium flake, 250#	10
PVB	2

Table 5. Snowball

When pumping stars that include more than 2% PVB, I find it best to use no more than 8 to 10% of alcohol (either isopropyl or ethyl) otherwise the mixes can tend to become somewhat soft and sticky. For those containing smaller amounts of PVB, I find it advantageous to slightly over-wet them, to ensure the PVB is well activated, and then wait until some of the alcohol evaporates before pumping. When making cut stars, I find that a little more alcohol is necessary to obtain the right consistency.

With PVB as the binder, all these compositions roll extremely well, producing even-sized, perfectly spherical stars. Whether rolling by hand or using a star roller, it seems almost impossible to produce misshapen rolled stars under any circumstances.

While most of these formulations produce what I consider to be good effects, I certainly don't claim that any of them is the best that can be obtained. I put them forward as examples of what can be accomplished, and as a potential starting point for further experimentation. KG

WHAT IS PVB?

Polyvinyl Butyral resin is a non-toxic, non-corrosive product with many industrial applications. It has high tensile strength, excellent adhesiveness, elasticity, is not photo-sensitive, and resists the effects of freezing and aging. MSDS shows no EPA problems but it is listed by the FDA when used as a food additive.

PVB is made by condensation reaction of polyvinyl alcohol and butyraldehyde: $H_2(C_8H_{14}O_2)_n$

When used as a binder/fuel in fireworks applications, use of the proper solvent becomes critical. Ethyl alcohol (95%) is the preferred solvent, although 95% isopropyl is acceptable. Methanol should be avoided.

Fireworks comps using PVB are sensitive to the amount of solvent added, with rapid viscosity changes apparent as solvent is added.

Some work with mixed solvents seems to show that a 50/50% mix of ethanol and toluene present the ideal solvent, although this is not present in the fireworks literature.