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### **Supporting Information**

# Green oxidizer based on 1,2,3-triazole with the high oxygen balance of +23.3%: A promising replacement of

# amommium perchloride in solid propellants

Pinxu Zhao<sup>a, b</sup>, Long Chen<sup>b</sup>, Qingzhong Zhang<sup>b</sup>, Yifei Ling<sup>b</sup>, Qiuhan Lin<sup>a</sup>\*, Haifeng Huang<sup>b</sup>\*, Jun Yang<sup>b</sup>\*

<sup>a</sup> School of Chemistry and Chemical Engineering, Nanjing University of Science and Technology, Xiaolingwei Road 200, Nanjing 210094, P.R. China.

<sup>b</sup> Key Laboratory of Fluorine and Nitrogen Chemistry and Advanced Materials, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Lingling Road 345, Shanghai, 200032, P.R. China.

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### **1. Experimental Section**

*Caution!* Although we have encountered no difficulties during preparation and handling of these compounds, they are potentially explosive energetic materials especially **JY-23** which is sensitive to impact and friction and should be synthesized in only small amounts. Mechanical actions of these energetic materials, involving scratching or scraping, must be avoided. Manipulations must be carried out by using appropriate standard safety precautions.

#### 5-Nitro-2-(2-oxopropyl)- 1,2,3-triazole-4-carbonitrile (2)



To the solution of 4-cyano-5-nitro-1*H*-1,2,3-triazole (1, 2.06 g, 14.8 mmol) in methanol was added excess solution of ammonia in methanol. After stirring at room temperature for 1 h, the solvent was removed to obtain the ammonium salt of compound 1, and then the ammonium salt was dissolved with DMF. To the solution of amonium salt of 4-cyano-5-nitro-1*H*-1,2,3-triazole in DMF (50 mL), chloroacetone (1.42 mL, 17.8 mmol) was added. Then the mixture system was heated to reflux for 12 h, and was poured into ice water. The off-white precipate (**2**) was filtered and dried by air (2.09 g). Yield: 75.0 %; <sup>1</sup>H NMR (d6-DMSO): 5.95 (s, 2H), 2.28 (s, 3H) ppm, <sup>13</sup>C NMR (d6-DMSO): 199.14, 154.13, 117.72, 109.23, 65.48, 27.10 ppm. IR (KBr):  $\tilde{v}$  3444, 2991, 2951, 2264, 1737, 1667, 1651, 1633, 1567, 1505, 1463, 1427, 1360, 1327, 1169, 859, 799, 767, 606, 545 cm<sup>-1</sup>. HRMS (ESI) calcd for C<sub>6</sub>H<sub>4</sub>O<sub>3</sub>N<sub>5</sub> [M-H]- 194.0320, found 194.0321.

(Z)-N'-hydroxy-2-((E)-2-(hydroxyimino)propyl)-5-nitro-2H-1,2,3-triazole-4carboximidamide (3)



To the suspension of compound **2** (1.8 g, 9.2 mmol) in water (13 mL), hydroxylamine (50wt% solution, 1.65 mL, 27.12 mmol) was added dropwise. Then the mixture system was heated to reflux for 3 h and then naturally cooled to room temperature, the reaction mixture was extracted with diethyl ether (60 mL×4). The combined organic phase was dried with anhydrous magnesium sulfate. After filtration, the diethyl ether was removed at reduced pressure to obtain compound **3** as a yellow powder. (2.04 g). Yield: 90.9%; <sup>1</sup>H NMR (d6-DMSO): 11.23 (s, 1H), 9.99 (s, 1H), 6.06 (s, 2H), 5.29 (s, 2H), 1.77 (s,

3H) ppm, <sup>13</sup>C NMR (d6-DMSO): 150.08, 149.52, 142.27, 136.19, 59.66, 11.91 ppm. IR (KBr):  $\tilde{v}$  3500, 3439, 3396, 3265, 2139, 1650, 1574, 1556, 1525, 1425, 1381, 1362, 1295, 1254, 1171, 1129, 1039, 952, 922, 852, 814, 798, 758, 636 cm<sup>-1</sup>. HRMS (ESI) calcd for C<sub>6</sub>H<sub>10</sub>O<sub>4</sub>N<sub>7</sub> [M+H]+ 244.0789, found 244.0791.

(Z)-N-hydroxy-5-nitro-2-(2-oxopropyl)-1,2,3-triazole-4-carbimidoyl chloride (4)



Compound **3** (2.0 g, 8.2 mmol) was dissolved in hydrochloric acid solution (45 mL, 20 %) at 0 °C. An aqueous solution of NaNO<sub>2</sub> (1.5 g, 8 mL) was dropped into the reaction system and the temperature was maintained at 0-5 °C for 2h, the reaction system was allowed to warm slowly up to room temperature and continued to stir for 3 h. the yellow precipitate (4) was collected and dried by air (1.55 g). Yield: 76.0 %;<sup>1</sup>H NMR(d6-DMSO): 13.24 (s, 1H) 5.85 (s, 2H) 2.27 (s, 3H) ppm, <sup>13</sup>C NMR(d6-DMSO): 199.77, 149.34, 135.52, 123.30, 64.89, 27.11 ppm. IR (KBr):  $\tilde{v}$  3379, 3286, 2987, 1728, 1559, 1524, 1431, 1417, 1355, 1323, 1178, 1019, 953, 835 cm<sup>-1</sup>; HRMS (ESI) calcd C6H6O4N5ClNa for [M+Na]+ 270.0001, found 270.0005.

Potassium dinitro(5-nitro-2-(2-oxopropyl)-1,2,3-triazol-4-yl)methanide (5)



Compound **4** (1.02 g, 4.1 mmol) was added dropwise into a stirred mixture of trifluoroacetic acid anhydride (6.5 mL), DCM (10 mL) and fuming HNO<sub>3</sub> (5 mL), while maintaining the reaction temperature < 0 °C. After the addition was complete, and the mixture was maintained at 0- 5 °C. It was stirred for 30 min, and then poured into ice water (40 mL) and extracted with DCM (60 × 4 mL). The organic phases were combined, washed with water and brine, dried over sodium sulfate, and then concentrated under vacuum to provide the intermediate as a yellow oil. The oil was dissolved in methanol (60 mL), potassium iodide (1.56 g, 8.3 mmol) in methanol (13 mL) was added dropwise, and the mixture was stirred overnight at room temperature. The precipitate formed was collected by filtration and washed with methanol to give **5** as a yellow solid (863 mg) Yield: 67.0 %; <sup>1</sup>H NMR(d6-DMSO):5.78(s, 2H), 2.25(s, 3H), <sup>13</sup>C NMR(d6-DMSO): 199.89, 149.46, 136.97, 123.08, 64.59, 27.14 ppm. IR (KBr):  $\tilde{v}$  2986, 2939, 1735, 1563, 1526, 1463, 1414, 1369, 1323, 1223, 1185, 1146,

1040, 1015, 851, 813, 760, 750, 578, 481 cm<sup>-1</sup>;

### 4-Nitro-2,5-bis(trinitromethyl)- 1,2,3-triazole (JY-23)



Compound **5** (400 mg, 2.06 mmol) was dissolved in 98% sulfuric acid (6 mL) at 0 °C After cooling to -5 °C, 100% nitric acid (4 mL) was added dropwise. The reaction mixture was stirred for 3 d at room temperature. Then it was poured into ice water (100 mL). The white precipitate (**JY-23**) was collected by filtration and dried by air (182 mg). Yield: 21.4 %. <sup>13</sup>C NMR(CDCl<sub>3</sub>): 153.3, 134.5, 119.7, 116.4 ppm. IR (KBr):  $\tilde{v}$  2880, 1647, 1635, 1613, 1600, 1578, 1513, 1392, 1362, 1331, 1273, 1210, 1074, 992, 942, 851, 837, 826, 791, 764, 698, 675, 648, 629 cm<sup>-1</sup>; Elemental analysis: Calcd (%) for C<sub>4</sub>N<sub>10</sub>O<sub>14</sub> (412.14): C 11.66, H 0.00, N 33.99; Found: C 11.72, H <0.30, N 33.40.

# 2.X-ray Crystallographic Date

CCDC	2256910
Empirical formula	C4 N10 O14
Formula weight	412.14
Temperature	293(2) K
Wavelength	0.71073 Å
Crystal system	Monoclinic
Space group	P 21/n
a/ Å	9.8357(6)
b/ Å	6.0788(4)
c/ Å	24.1733(15)
α(°)	90
β(°)	101.280(2)
γ(°)	90
Volume	1417.38(15) Å <sup>3</sup>
Z	4
Density (calculated)	1.931 Mg/m <sup>3</sup>
Absorption coefficient	0.197 mm <sup>-1</sup>
F(000)	824
Crystal size	0.180 x 0.100 x 0.050 mm <sup>3</sup>
Theta range for data collection	2.430 to 25.497°.
Index ranges	-11<=h<=11, -7<=k<=7, - 29<=l<=28
Reflections collected	13728
Independent reflections	2626 [R(int) = 0.0584]
Completeness to theta = $25.242^{\circ}$	99.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7456 and 0.5894
Refinement method	Full-matrix least-squares on F <sup>2</sup>
Data / restraints / parameters	2626 / 0 / 253
Goodness-of-fit on F <sup>2</sup>	1.042
Final R indices [I>2sigma(I)]	R1 = 0.0558, wR2 = 0.1359
R indices (all data)	R1 = $0.0851$ , wR2 = $0.1593$

Table S1. Crystal data and structure refinement for **JY-23**.

Extinction coefficient	n/a	
Largest diff. peak and hole	0.354 and -0.222 e.Å <sup>-3</sup>	

Z U(eq) х у O(1) 5449(5) 2416(1) 85(1) 1313(3) O(2) 475(2) 2932(1) 80(1) 7764(5) O(3) 888(3) 5857(5) 4081(1) 90(1) O(4) 721(3) 8290(5) 4708(1) 95(1) O(5) 196(3) 3801(1) 89(1) 11194(5) O(6) 1988(3) 84(1) 11822(5) 3428(1) O(7) 3214(3) 12084(5) 4587(1) 95(1) O(8) 3633(3) 8824(5) 4952(1) 88(1) O(9) 7343(3) 8161(6) 4147(2) 108(1) O(10) 7448(4) 4851(6) 4432(1) 116(1)O(11) 6066(4) 7109(7) 2671(2) 121(1)6479(11) O(12) 8020(4) 3168(2) 194(3) O(13) 6966(4) 2253(7) 3266(2) 131(1) O(14) 5300(3) 2175(5) 3725(1) 92(1) N(1) 4385(2) 7506(4) 3936(1) 54(1) N(2) 4780(2) 6351(4) 3527(1) 55(1) N(3) 3787(3) 5799(4) 3087(1) 56(1) N(4) 1390(3) 2826(1) 6598(5) 61(1) N(5) 1162(3) 7550(5) 4315(1) 64(1) N(6) 1351(3) 10853(5) 3735(1) 65(1) N(7) 3105(3) 4596(1) 69(1) 10116(6) N(8) 7089(3) 6283(7) 4106(1) 72(1) N(9) 6809(3) 6471(7) 3056(2) 85(1) N(10) 6147(4) 3055(6) 78(1) 3515(1) C(1) 3043(3) 50(1) 7779(5) 3745(1) C(2) 2703(3) 50(1) 6713(5) 3221(1) C(3) 2183(3) 9022(5) 4081(1) 55(1) C(4) 3549(1) 60(1) 6157(3) 5581(6)

Table S2. Atomic coordinates (  $x \ 10^4$ ) and equivalent isotropic displacement parameters (Å<sup>2</sup>x 10<sup>3</sup>) for **JY-23**. U(eq) is defined as one third of the trace of the orthogonalized U<sup>ij</sup> tensor.

O(1)-N(4)	1.203(4)
O(2)-N(4)	1.211(4)
O(3)-N(5)	1.180(4)
O(4)-N(5)	1.207(4)
O(5)-N(6)	1.195(4)
O(6)-N(6)	1.213(4)
O(7)-N(7)	1.202(4)
O(8)-N(7)	1.206(4)
O(9)-N(8)	1.169(4)
O(10)-N(8)	1.181(4)
O(11)-N(9)	1.133(4)
O(12)-N(9)	1.169(4)
O(13)-N(10)	1.200(4)
O(14)-N(10)	1.185(4)
N(1)-C(1)	1.320(4)
N(1)-N(2)	1.331(4)
N(2)-N(3)	1.338(3)
N(2)-C(4)	1.424(4)
N(3)-C(2)	1.299(4)
N(4)-C(2)	1.449(4)
N(5)-C(3)	1.533(4)
N(6)-C(3)	1.530(4)
N(7)-C(3)	1.540(4)
N(8)-C(4)	1.534(4)
N(9)-C(4)	1.558(5)
N(10)-C(4)	1.537(5)
C(1)-C(2)	1.404(4)
C(1)-C(3)	1.488(4)
C(1)-N(1)-N(2)	103.0(2)
N(1)-N(2)-N(3)	116.7(2)
N(1)-N(2)-C(4)	123.9(2)
N(3)-N(2)-C(4)	119.3(3)
C(2)-N(3)-N(2)	101.6(2)
O(1)-N(4)-O(2)	125.7(3)
O(1)-N(4)-C(2)	118.4(3)

Table S3. Bond lengths [Å] and angles [°] for **JY-23**.

O(2)-N(4)-C(2)	115.9(3)
O(3)-N(5)-O(4)	128.3(3)
O(3)-N(5)-C(3)	116.0(3)
O(4)-N(5)-C(3)	115.8(3)
O(5)-N(6)-O(6)	128.0(3)
O(5)-N(6)-C(3)	118.3(3)
O(6)-N(6)-C(3)	113.7(3)
O(7)-N(7)-O(8)	129.4(3)
O(7)-N(7)-C(3)	117.1(3)
O(8)-N(7)-C(3)	113.5(3)
O(9)-N(8)-O(10)	129.3(4)
O(9)-N(8)-C(4)	115.3(3)
O(10)-N(8)-C(4)	115.4(4)
O(11)-N(9)-O(12)	130.9(4)
O(11)-N(9)-C(4)	116.9(3)
O(12)-N(9)-C(4)	112.1(4)
O(14)-N(10)-O(13)	128.9(4)
O(14)-N(10)-C(4)	115.2(3)
O(13)-N(10)-C(4)	115.8(4)
N(1)-C(1)-C(2)	107.6(3)
N(1)-C(1)-C(3)	120.7(3)
C(2)-C(1)-C(3)	131.8(3)
N(3)-C(2)-C(1)	111.1(3)
N(3)-C(2)-N(4)	118.9(3)
C(1)-C(2)-N(4)	129.9(3)
C(1)-C(3)-N(6)	111.8(3)
C(1)-C(3)-N(5)	112.8(3)
N(6)-C(3)-N(5)	107.9(2)
C(1)-C(3)-N(7)	110.6(2)
N(6)-C(3)-N(7)	107.2(3)
N(5)-C(3)-N(7)	106.2(3)
N(2)-C(4)-N(8)	110.0(3)
N(2)-C(4)-N(10)	109.3(3)
N(8)-C(4)-N(10)	108.8(3)
N(2)-C(4)-N(9)	112.8(3)
N(8)-C(4)-N(9)	108.1(3)
N(10)-C(4)-N(9)	107.7(3)

Symmetry transformations used to generate equivalent atoms:

	$U^{11}$	U <sup>22</sup>	U <sup>33</sup>	U <sup>23</sup>	U <sup>13</sup>	U <sup>12</sup>
	94(2)	00(2)	50/2)	10/2)	14(1)	4(2)
0(1)	84(2)	99(2)	59(2)	-19(2)	-14(1)	4(2)
O(2)	48(1)	112(2)	76(2)	-11(2)	0(1)	6(1)
O(3)	96(2)	78(2)	104(2)	-12(2)	43(2)	-22(2)
O(4)	86(2)	111(2)	99(2)	-14(2)	47(2)	-2(2)
O(5)	59(2)	86(2)	120(2)	-1(2)	12(2)	16(1)
O(6)	86(2)	73(2)	91(2)	16(2)	15(2)	2(1)
O(7)	92(2)	80(2)	103(2)	-29(2)	-2(2)	-12(2)
O(8)	79(2)	119(2)	57(2)	-6(2)	-3(1)	2(2)
O(9)	74(2)	106(3)	130(3)	0(2)	-14(2)	-17(2)
O(10)	110(2)	129(3)	94(2)	21(2)	-21(2)	-11(2)
O(11)	100(2)	174(4)	97(2)	44(2)	36(2)	-9(2)
O(12)	76(2)	361(8)	155(4)	75(4)	47(2)	-8(3)
O(13)	118(3)	139(3)	142(3)	-12(2)	44(2)	50(2)
O(14)	79(2)	84(2)	110(2)	20(2)	10(2)	-6(2)
N(1)	44(1)	65(2)	50(1)	-1(1)	6(1)	-5(1)
N(2)	41(1)	67(2)	54(2)	0(1)	6(1)	-1(1)
N(3)	53(2)	66(2)	47(1)	1(1)	6(1)	-2(1)
N(4)	54(2)	74(2)	50(2)	-2(1)	1(1)	-3(2)
N(5)	52(2)	76(2)	68(2)	-2(2)	18(1)	4(2)
N(6)	56(2)	60(2)	76(2)	-6(2)	4(2)	2(1)
N(7)	55(2)	88(2)	61(2)	-19(2)	5(1)	-3(2)
N(8)	48(2)	86(2)	77(2)	3(2)	2(2)	-2(2)
N(9)	46(2)	127(3)	86(2)	28(2)	20(2)	-2(2)
N(10)	62(2)	87(2)	82(2)	1(2)	7(2)	16(2)
C(1)	44(2)	57(2)	48(2)	2(1)	5(1)	-4(1)
C(2)	43(2)	58(2)	47(2)	2(1)	2(1)	-3(1)
C(3)	44(2)	63(2)	55(2)	-4(2)	5(1)	-2(1)
C(4)	44(2)	76(2)	62(2)	8(2)	9(2)	2(2)

Table S4. Anisotropic displacement parameters (Å<sup>2</sup>x 10<sup>3</sup>) for **JY-23**. The anisotropic displacement factor exponent takes the form:  $-2\pi^2$ [ h<sup>2</sup> a<sup>\*2</sup>U<sup>11</sup> + ... + 2 h k a<sup>\*</sup> b<sup>\*</sup> U<sup>12</sup> ]

Table S5. Torsion angles [°] for **JY-23**.

C(1)-N(1)-N(2)-N(3)	-1.6(3)
C(1)-N(1)-N(2)-C(4)	-177.7(3)
N(1)-N(2)-N(3)-C(2)	1.6(3)
C(4)-N(2)-N(3)-C(2)	178.0(3)
N(2)-N(1)-C(1)-C(2)	0.8(3)
N(2)-N(1)-C(1)-C(3)	-179.8(3)
N(2)-N(3)-C(2)-C(1)	-1.0(3)
N(2)-N(3)-C(2)-N(4)	176.4(3)
N(1)-C(1)-C(2)-N(3)	0.2(4)
C(3)-C(1)-C(2)-N(3)	-179.2(3)
N(1)-C(1)-C(2)-N(4)	-176.9(3)
C(3)-C(1)-C(2)-N(4)	3.7(6)
O(1)-N(4)-C(2)-N(3)	8.3(4)
O(2)-N(4)-C(2)-N(3)	-168.7(3)
O(1)-N(4)-C(2)-C(1)	-174.8(3)
O(2)-N(4)-C(2)-C(1)	8.2(5)
N(1)-C(1)-C(3)-N(6)	127.3(3)
C(2)-C(1)-C(3)-N(6)	-53.4(4)
N(1)-C(1)-C(3)-N(5)	-110.9(3)
C(2)-C(1)-C(3)-N(5)	68.4(4)
N(1)-C(1)-C(3)-N(7)	7.9(4)
C(2)-C(1)-C(3)-N(7)	-172.8(3)
O(5)-N(6)-C(3)-C(1)	141.7(3)
O(6)-N(6)-C(3)-C(1)	-39.8(4)
O(5)-N(6)-C(3)-N(5)	17.1(4)
O(6)-N(6)-C(3)-N(5)	-164.4(3)
O(5)-N(6)-C(3)-N(7)	-96.9(3)
O(6)-N(6)-C(3)-N(7)	81.6(3)
O(3)-N(5)-C(3)-C(1)	-21.1(4)
O(4)-N(5)-C(3)-C(1)	160.2(3)
O(3)-N(5)-C(3)-N(6)	102.9(3)
O(4)-N(5)-C(3)-N(6)	-75.9(3)
O(3)-N(5)-C(3)-N(7)	-142.4(3)
O(4)-N(5)-C(3)-N(7)	38.8(4)
O(7)-N(7)-C(3)-C(1)	109.1(3)
O(8)-N(7)-C(3)-C(1)	-70.0(4)

O(7)-N(7)-C(3)-N(6)	-13.0(4)
O(8)-N(7)-C(3)-N(6)	167.9(3)
O(7)-N(7)-C(3)-N(5)	-128.1(3)
O(8)-N(7)-C(3)-N(5)	52.7(3)
N(1)-N(2)-C(4)-N(8)	-0.1(4)
N(3)-N(2)-C(4)-N(8)	-176.2(3)
N(1)-N(2)-C(4)-N(10)	119.3(3)
N(3)-N(2)-C(4)-N(10)	-56.8(4)
N(1)-N(2)-C(4)-N(9)	-121.0(3)
N(3)-N(2)-C(4)-N(9)	63.0(4)
O(9)-N(8)-C(4)-N(2)	-70.9(4)
O(10)-N(8)-C(4)-N(2)	109.2(4)
O(9)-N(8)-C(4)-N(10)	169.4(3)
O(10)-N(8)-C(4)-N(10)	-10.5(4)
O(9)-N(8)-C(4)-N(9)	52.7(4)
O(10)-N(8)-C(4)-N(9)	-127.2(4)
O(14)-N(10)-C(4)-N(2)	-32.7(4)
O(13)-N(10)-C(4)-N(2)	145.1(3)
O(14)-N(10)-C(4)-N(8)	87.5(4)
O(13)-N(10)-C(4)-N(8)	-94.7(4)
O(14)-N(10)-C(4)-N(9)	-155.5(3)
O(13)-N(10)-C(4)-N(9)	22.3(4)
O(11)-N(9)-C(4)-N(2)	-19.6(5)
O(12)-N(9)-C(4)-N(2)	156.0(5)
O(11)-N(9)-C(4)-N(8)	-141.5(4)
O(12)-N(9)-C(4)-N(8)	34.1(6)
O(11)-N(9)-C(4)-N(10)	101.1(5)
O(12)-N(9)-C(4)-N(10)	-83.4(5)

Symmetry transformations used to generate equivalent atoms:

# 3. NMR Spectrum of the prepared compounds



Figure S1 <sup>1</sup>H NMR spectrum of compound **2** in  $d_6$ -DMSO.



Figure S2 <sup>13</sup>C NMR spectrum of compound **2** in  $d_6$ -DMSO.



Figure S3 <sup>1</sup>H NMR spectrum of compound **3** in  $d_6$ -DMSO.



Figure S4 <sup>13</sup>C NMR spectrum of compound **3** in  $d_6$ -DMSO.



Figure S5 <sup>1</sup>H NMR spectrum of compound 4 in  $d_6$ -DMSO.



Figure S6 <sup>13</sup>C NMR spectrum of compound 4 in  $d_6$ -DMSO.



Figure S8 <sup>13</sup>C NMR spectrum of compound **5** in  $d_6$ -DMSO.



Figure S9 <sup>1</sup>H NMR spectrum of compound **JY-23** in  $d_6$ -DMSO.



Figure S10 <sup>13</sup>C NMR spectrum of compound **JY-23** in CDCl<sub>3</sub>.

# 4. IR Spectrum and HRMS (ESI) spectrometry of the prepared



Figure S11 IR spectrum of compound 2.



Figure S12 IR spectrum of compound **3**.







Figure S14 IR spectrum of compound 5.



Figure S15 IR spectrum of compound JY-23.



Figure S16 HRMS (ESI) spectrometry of compound 2.

National Center for Organic Mass Spectrometry in Shanghai Shanghai Institute of Organic Chemistry Chinese Academic of Sciences High Resolution ESI-MS/MS REPORT

Instrument: Thermo Scientific Q Exactive HF Orbitrap-FTMS
Card Serial Number: E240295
Sample Serial Number: ZPX-5-7
Operator: Songw Date: 2024/02/02
Operation Mode: ESI Positive Ion Mode
Elemental composition search on mass 244.0791
m/7= 239 0791-249 0791 HO
m/z Theo. Delta RDB Composition Mass (ppm) equiv.
244.0791 244.0789 0.91 5.5 C6 H10 O4 N7

Figure S17 HRMS (ESI) spectrometry of compound 3.

	Shanghai Institute of Organic Che Chinese Academic of Science High Resolution ESI-MS/MS REI	mistry 95 PORT
Instrument: Thermo Sc	ientific Q Exactive HF Orbitrap-F7	ſMS
Card Serial Number: E24	40302	
Sample Serial Number:	ZPX-5-9	
Operator: Songw	Date: 2024/02/02	
Operation Mode: ESI	Positive Ion Mode	N N
Elemental composition	a search on mass 270.0005	
m/z= 265.0005-275.00 m/z   Theo.	05 Delta   RDB   Compositio	on of the second
Mass 270.0005 270.0001	(ppm) equiv. 1.84 5.5 C6H6O4N5Cl	Na

Figure S18 HRMS (ESI) spectrometry of compound 4.



5. TG-DSC curves and chemical stability of JY-23

Figure S19 TG-DSC curve of JY-23.



The properties of JY-23



The weight monitoring of JY-23 (including bottle weight)



IR spectra of solid compounds exposed to air for various time periods Figure S20 Investigation of chemical stability of **JY-23**.

### 6. Computations



Figure S21 The electrostatic potential (ESP) on the molecular surface of **JY-23** (The geometric optimization was accomplished by using the B3LYP6-311G++(d, p) basis set.)

The G4(MP2)<sup>1,2</sup> method was used for calculation the enthalpy of JY-23. Calculations at the same levels of theory were performed for isolated atoms, which are used as reference for extracting the enthalpy of formation.<sup>3</sup> Above quantum calculations were performed using the Orca 5.0.3 <sup>4,5</sup> and pople python package.<sup>6,7</sup>

С	0.47180108	-1.44356749	-0.04947104
С	0.88650591	-0.08611149	-0.04040649
Ν	-1.19761437	-0.22832571	-0.06645277
Ν	-0.83919193	-1.51050220	-0.05714622
Ν	-0.20016606	0.66382499	-0.04333290
С	-2.56617672	0.13690295	-0.01142239
С	2.24711180	0.51380521	-0.02278738
Ν	3.04113171	0.04044691	1.22967853
0	4.24033857	0.00186281	1.14963437
0	2.33341366	-0.20363563	2.18309578
Ν	2.15836649	2.05899718	0.06298458
0	2.42889266	2.56101147	1.12739329
0	1.80374230	2.59172728	-0.96315141
Ν	3.04643184	0.22137653	-1.31315475
0	2.56659221	-0.60456604	-2.06110399
0	4.06109102	0.85958407	-1.45087021
Ν	-2.70474299	1.67221302	0.13544148
0	-2.42133183	2.28842096	-0.86280071
0	-3.08219680	2.07395286	1.20866223
Ν	-3.23825890	-0.54634399	1.22779497
0	-2.51880067	-0.61801629	2.19444407
0	-4.38287661	-0.89849196	1.09304379
Ν	-3.36277525	-0.25599109	-1.28924763

### **Optimized Cartesian coordinates of JY-23**

0	-2.86367825	-1.09820750	-1.99535291
0	-4.40959202	0.33226120	-1.41829327
Ν	1.29004797	-2.64586955	-0.01705154
0	2.48759236	-2.44961761	0.15537281
0	0.73400306	-3.71269638	-0.15274195

The enthalpy of sublimation of JY-23 were calculated using the equation reported by Byrd and Rice.<sup>8</sup>

$$\Delta H_{sub} = a(SA)^2 + b\sqrt{(\sigma_{tor}^2 \nu)} + c$$

a = 0.000267, b = 1.650087, c = 2.966078

where SA is the surface area of the 0.001 electron/bohr<sup>3</sup> isosurface of the electron density of the molecule,  $\sigma_{tot}^2$  is a measure of the variability of electronic potential on the surface, and v is the degree of balance between the positive and negative charges on the isosurface. According to ref 1, the geometry of JY-23 was optimized at B3LYP<sup>9</sup>/6-31G\*\* level and the wave function analysis was conducted at B3LYP/6-311++G(2df,2p) level using Gaussian16.<sup>x</sup> Above parameters were obtained using Multiwfn.<sup>10</sup>

$$\Delta H_{solid} = \Delta H_{gas} - \Delta H_{sub}$$

Finally, based on the calculated enthalpy of formation in gaseous state and sublimation state, the enthalpy of formation in solid state of **JY-23** was estimated by subtracting the heats of sublimation from gas-phase values.

compound	$\Delta H_{gas}/\text{kJ/mol}$	$\Delta H_{sub}$ /kcal/mol	⊿H <sub>solid</sub> /kJ/mol
JY-23	437.22583	34.037673	294.81

### Specific impact calculation

The energy properties of **JY-23** in HTPB and GAP propellants were studied by using NASA-CEA software at  $p_c = 70$  atm,  $p_e = 1$  atm,  $T_0 = 298$  K, and compared with other heterocyclic oxidizers (**A**, **B** and **C**) in detail.  $I_{sp}$  is the theoretical specific impulse,  $C^*$  is the characteristic velocity,  $T_c$  is the combustion chamber temperature,  $M_e$  is the relative average molecular weight of the combustion product at the engine nozzle.

Table S6 Energy performance of AP/GAP/Al and AP/HTPB/Al propellants.

				1 1		
Codes	Propellant formulas	I <sub>sp</sub> /N s/kg	<i>C</i> */m/s	$T_{\rm c}/{ m K}$	Me	$I_{\rm sp}/{ m s}$
GAP-1	AP <sub>62%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub>	2610.6	1584.1	3758.4	29.78	266.4
				8	5	
GAP-2-A		2616.6	1587.7	3785.4	29.89	267.0
	AP <sub>57%</sub> /GAP <sub>20%</sub> /AI <sub>18%</sub> /A <sub>5%</sub>			1	5	
GAP-3-A		2622.6	1591.3	3812.6	30.00	267.6
	AP <sub>52%</sub> /GAP <sub>20%</sub> /AI <sub>18%</sub> /A <sub>10%</sub>			5	5	

GAP-4-A	AP <sub>47%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /A <sub>15%</sub>	2628.6	1594.9	3840.2 1	30.11 7	268.2
GAP-5-A	AP42%/GAP20%/Al18%/A20%	2634.6	1598.5	3868.0 9	30.22 9	268.8
GAP-6-A	AP37%/GAP20%/Al18%/A25%	2640.6	1602	3896.2 7	30.34 3	269.4
GAP-7-A	AP32%/GAP20%/Al18%/A30%	2646.6	1605.6	3924.7 2	30.45 9	270.1
GAP-8-A	AP <sub>27%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /A <sub>35%</sub>	2652.6	1609.1	3953.3 2	30.57 7	270.7
GAP-9-A	AP22%/GAP20%/Al18%/A40%	2658.6	1612.6	3981.9	30.69 7	271.3
GAP-10-A	AP <sub>17%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /A <sub>45%</sub>	2664.4	1615.8	4010.1 1	30.82 1	271.9
GAP-11-A	AP12%/GAP20%/Al18%/A50%	2669.9	1618.8	4037.3 7	30.94 9	272.4
GAP-12-A	AP7%/GAP20%/Al18%/A55%	2674.7	1621.3	4062.7 3	31.08 2	272.9
GAP-13-A	GAP <sub>20%</sub> /Al <sub>18%</sub> /A <sub>62%</sub>	2677.6	1623.1	4092.3 6	31.27 8	273.2
GAP-1	AP <sub>62%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub>	2610.6	1584.1	3758.4 8	29.78 5	266.4
GAP-2-B	AP57%/GAP20%/Al18%/B5%	2614.5	1586.3	3784.6 9	29.93 8	266.8
GAP-3-B	AP52%/GAP20%/Al18%/B10%	2618.4	1588.5	3811.3 9	30.09 2	267.2
GAP-4-B	AP47%/GAP20%/Al18%/B15%	2622.3	1590.8	3838.6 3	30.24 8	267.6
GAP-5-B	AP42%/GAP20%/Al18%/B20%	2626.3	1593	3866.4 7	30.40 6	268.0
GAP-6-B	AP37%/GAP20%/Al18%/B25%	2630.2	1595.4	3894.9 6	30.56 6	268.4
GAP-7-B	AP32%/GAP20%/Al18%/B30%	2634.3	1597.7	3924.1 7	30.72 9	268.8
GAP-8-B	AP27%/GAP20%/Al18%/B35%	2638.4	1600.1	3954.1 2	30.89 4	269.2
GAP-9-B	AP22%/GAP20%/Al18%/B40%	2642.7	1602.5	3984.8 4	31.06 3	269.7
GAP-10-B	AP17%/GAP20%/Al18%/B45%	2647	1605	4016.2 9	31.23 7	270.1
GAP-11-B	AP12%/GAP20%/Al18%/B50%	2651.4	1607.4	4048.3 2	31.41 5	270.6
GAP-12-B	AP7%/GAP20%/Al18%/B55%	2655.9	1609.7	4080.6	31.59	271.0

GAP-13-BGAP200/Al188/B82% GAP200/Al188/C82% C60AP12662.11612.64125.1 431.86 8271.6GAP-11AP62%/GAP200/Al18% C60AP200/Al18%/C50% GAP-3-CAP62%/GAP200/Al18%/C50% AP57%/GAP200/Al18%/C10% AP57%/GAP200/Al18%/C10% 2619.31590.43773.2 329.77 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3261.51587.3 <th></th> <th></th> <th></th> <th></th> <th>2</th> <th>0</th> <th></th>					2	0	
GAP-13-B $GAP_{200}/Al_{1890}/B_{6276}$ $2662.1$ $1612.6$ $412.1$ $4$ $31.86$ $8$ $271.6$ GAP-1 $AP_{6270}/GAP_{2070}/Al_{1890}/C_{576}$ $2610.6$ $1584.1$ $378.4$ $8$ $29.78$ 					2		
Interface <td>GAP-13-B</td> <td><math>GAP_{20\%}/Al_{18\%}/B_{62\%}</math></td> <td>2662.1</td> <td>1612.6</td> <td>4125.1</td> <td>31.86</td> <td>271.6</td>	GAP-13-B	$GAP_{20\%}/Al_{18\%}/B_{62\%}$	2662.1	1612.6	4125.1	31.86	271.6
GAP-1         AP <sub>62%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> 2610.6         1584.1         3758.4         29.78 8         266.4           GAP-2-C         AP <sub>57%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>5%</sub> 2615         1587.3         373.2         29.77 3         267.3           GAP-3-C         AP <sub>52%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>10%</sub> 2619.3         1590.4         3787.9         29.77 4         267.3           GAP-4-C         AP <sub>47%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>10%</sub> 2623.6         1593.6         3802.5         29.76 5         267.7           GAP-5-C         AP <sub>47%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>20%</sub> 2627.9         1596.7         7         8         268.2           GAP-6-C         AP <sub>37%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>25%</sub> 2632.1         1599.7         3816.9         29.75         268.6           GAP-7-C         AP <sub>27%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>35%</sub> 2640.1         1605.4         387.4         29.74         269.0           GAP-8-C         AP <sub>27%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>35%</sub> 2640.1         1601.1         387.83         29.72         270.4           GAP-10-C         AP <sub>17%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>45%</sub> 2647.1         1610.1         3884.2         29.72         270.4           GAP-11-C         AP <sub>17%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>55%</sub> 2650.2         1611.6         384.2		2070 1070 0270	200211		4	8	
GAP-1AF6229/GAP209/A1189/C 59% GAP209/A1189/C 59%2610.61584.185206.4GAP-2-CAP579/GAP209/A1189/C 59% AP297/GAP209/A1189/C 10%2619.31587.3 $3773.2$ 329.77 8267.3GAP-3-CAP579/GAP209/A1189/C 10% AP290/A1189/C 20%2623.61593.6 $3802.5$ 529.76 5267.7GAP-5-CAP429/GAP209/A1189/C 20% AP290/A1189/C 20%2627.91596.7 $381.0$ 729.75 8268.2GAP-6-CAP399/GAP209/A1189/C 20% AP290/A1189/C 30%2636.21602.6 $3844.6$ 829.74 	CAD 1		2(10)	1504 1	3758.4	29.78	266.4
GAP-2-CAP $_{57\%}/GAP_{20\%}/A1_{18\%}/C_{5\%}$ 26151587.3 $3773.2$ 3 $29.77$ 8266.8GAP-3-CAP $_{52\%}/GAP_{20\%}/A1_{18\%}/C_{10\%}$ 2619.31590.4 $3787.9$ $29.77$ 4267.3GAP-4-CAP $_{47\%}/GAP_{20\%}/A1_{18\%}/C_{10\%}$ 2623.61593.6 $55$ $55$ $267.7$ GAP-5-CAP $_{42\%}/GAP_{20\%}/A1_{18\%}/C_{20\%}$ 2627.91596.7 $3816.9$ 7 $29.75$ 8268.2GAP-6-CAP $_{37\%}/GAP_{20\%}/A1_{18\%}/C_{20\%}$ 2632.11599.7 $77$ 7 $22$ 268.6GAP-7-CAP $_{32\%}/GAP_{20\%}/A1_{18\%}/C_{30\%}$ 2636.21602.6 $884.6$ 8 $29.74$ 6269.0GAP-8-CAP $_{27\%}/GAP_{20\%}/A1_{18\%}/C_{30\%}$ 2640.11605.4 $87.3$ 8269.3GAP-9-CAP $_{22\%}/GAP_{20\%}/A1_{18\%}/C_{40\%}$ 2643.81608 $886.9$ 829.72 4269.4GAP-10-CAP $_{17\%}/GAP_{20\%}/A1_{18\%}/C_{40\%}$ 2647.11610.1 $887.3$ 829.72 3270.4GAP-11-CAP $_{17\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2650.21611.8 $3884.2$ 829.72 3270.4GAP-13-CGAP $_{20\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2650.21611.8 $3884.2$ 829.72 3260.4GAP-13-CGAP $_{20\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2610.61584.1 $375.4$ 829.73 8261.4GAP-13-CGAP $_{20\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2610.61584.1 $375.4$ 829.72 8261.6GAP-13-C3AP $_{$	GAP-1	AP <sub>62%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub>	2010.0	1584.1	8	5	200.4
GAP-2-C         AP <sub>579/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>595</sub> 2615         1587.3         37.3         87.4         266.8           GAP-3-C         AP <sub>529/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>1095</sub> 2619.3         1590.4         3787.9         29.77         267.3           GAP-4-C         AP <sub>479/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>1956</sub> 2623.6         1593.6         3816.9         29.77         267.3           GAP-5-C         AP <sub>429/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>2056</sub> 2627.9         1596.7         3816.9         29.75         268.2           GAP-5-C         AP <sub>329/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>2556</sub> 2632.1         1599.7         3831.0         29.75         268.2           GAP-7-C         AP <sub>329/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>2556</sub> 2636.2         1602.6         384.6         29.74         269.4           GAP-8-C         AP <sub>279/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>3076</sub> 2643.8         1608         3868.9         29.73         269.8           GAP-10-C         AP <sub>179/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>4076</sub> 2647.1         1610.1         3878.3         29.72         270.4           GAP-11-C         AP <sub>179/</sub> GAP <sub>209/</sub> Al <sub>189/</sub> C <sub>6276</sub> 2647.1         1610.1         3878.3         29.72         270.4           GAP-11-C         AP <sub>179//</sub> GAP <sub>209/</sub> Al <sub>189//</sub> C <sub>6276</sub> 2645.3         1607.7					3773.2	29 77	
GAP-3-CAP52%/GAP20%/A118%/C10%2619.31590.4378.7929.77267.3GAP-4-CAP47%/GAP20%/A118%/C15%2623.61593.63802.555267.7GAP-5-CAP42%/GAP20%/A118%/C20%2627.91596.7381.6.929.75268.2GAP-6-CAP37%/GAP20%/A118%/C20%2632.11599.772268.6GAP-7-CAP32%/GAP20%/A118%/C30%2636.21602.63844.629.74269.0GAP-8-CAP27%/GAP20%/A18%/C30%2640.11605.43857.429.72269.8GAP-9-CAP22%/GAP20%/A18%/C30%2643.816083868.929.73269.8GAP-10-CAP17%/GAP20%/A18%/C40%2643.81601.13878.329.72270.1GAP-11-CAP12%/GAP20%/A18%/C50%2649.61611.63884.229.72270.4GAP-12-CAP7%/GAP20%/A18%/C50%2649.61611.83884.229.72270.4GAP-13-CGAP20%/A18%/C50%2650.21611.8386.929.72270.4GAP-13-CAP7%/GAP20%/A18%/C50%2617.61584.1378.425266.9GAP-13-CAP5%/GAP20%/A18%/C50%2617.61584.1378.429.72270.4GAP-13-CAP5%/GAP20%/A18%/JY- 235%2617.61584.1378.429.73266.9GAP-3JY-23AP5%/GAP20%/A18%/JY- 235%2617.61588.1378.929.72270.4GAP-4JY-23AP5%/GAP20%/A18%/JY- 235%261.6159638	GAP-2-C	$AP_{57\%}/GAP_{20\%}/Al_{18\%}/C_{5\%}$	2615	1587.3	3	8	266.8
GAP-3-CAP_{3256}/GAP_{2079}/A1_{1856}/C_{1056}2619.31590.4 $376.7,3$ $27,7/4$ 267.3GAP-4-CAP_{4756}/GAP_{2079}/A1_{1856}/C_{1556}2623.61593.6555267.7GAP-5-CAP_{4256}/GAP_{2079}/A1_{1856}/C_{2056}2627.91596.7 $3816.9,7$ 29.75268.2GAP-6-CAP_{3756}/GAP_{2079}/A1_{1856}/C_{2056}2632.11599.7 $7$ $8$ 269.0GAP-7-CAP_{3256}/GAP_{2079}/A1_{1856}/C_{3056}2636.21602.6 $3844.6,8$ 29.74269.0GAP-8-CAP_{2756}/GAP_{2079}/A1_{1856}/C_{3056}2640.11605.4 $7$ 29.74269.0GAP-9-CAP_{2256}/GAP_{2079}/A1_{1856}/C_{4056}2643.81608 $3868.9,8$ 29.73269.8GAP-10-CAP_{1756}/GAP_{2079}/A1_{1856}/C_{4056}2647.11610.1 $3878.3,8$ 29.72270.1GAP-11-CAP_{1756}/GAP_{2079}/A1_{1856}/C_{5555}2650.21611.6 $3884.2,8$ 29.72270.4GAP-11-CAP_{1256/GAP_{2076}/A1_{1856}/C_{5555}2650.21611.8 $3884.2,8$ 29.72270.4GAP-13-CGAP_{2076}/A1_{1856}/C_{5256}2650.21611.8 $3884.2,8$ 29.72270.4GAP-13-CAP_{576/GAP_{2076}/A1_{1856}/C_{5256}2610.61584.1 $3758.4,8$ 29.78266.4GAP-13-CAP_{576/GAP_{2076}/A1_{1856}/C_{5256}1601.6388.19,930.20,6267.1GAP-13-CAP_{576/GAP_{2076}/A1_{186}/C_{5256}2610.61584.1 $3758.4,8$ 29.72<					2797.0	20.77	
GAP-4-CAP4794/GAP2094/A1894/C15% C15%2623.61593.6 $\frac{4}{5}$ 1GAP-4-CAP4794/GAP2094/A1894/C15% C3PA2627.91593.6 $\frac{3802.5}{5}$ 29.75 8268.2GAP-5-CAP4294/GAP2094/A1894/C25% C3PA2632.11599.7 $\frac{7}{7}$ 2 2268.2GAP-6-CAP3794/GAP2094/A1894/C25% C3PA2636.21602.6 $\frac{384.6}{8}$ 29.75 6269.0GAP-7-CAP2294/GAP2094/A1894/C35% C3PA2640.11605.4 $\frac{7}{7}$ 29.74 2269.0GAP-8-CAP2294/GAP2094/A1894/C45% C4PA2643.81608 $\frac{386.9}{8}$ 29.73 4269.8GAP-10-CAP2294/GAP2094/A1894/C45% C4PA2647.11610.1 $\frac{3873.3}{8}$ 29.72 8270.1GAP-11-CAP1294/GAP2094/A1894/C45% C4P2094/A1894/C45%2649.61611.6 $3884.2$ 29.72 8270.4GAP-11-CAP1294/GAP2094/A1894/C45% C4P2094/A1894/C45%2649.61611.6 $3884.2$ 29.72 8270.4GAP-13-CGAP2094/A1894/C45% C4P2094/A1894/C45%2650.21611.8 $3884.2$ 829.72 8270.4GAP-13-CAP4594/GAP2094/A1894/C45% C35%2661.61584.1 $3758.4$ 829.78 8266.9GAP-13-CAP4594/GAP2094/A1894/C45% C35%2610.61584.1 $3758.4$ 829.78 5266.7GAP-13-CAP4594/GAP2094/A1894/C45% C35%2610.61584.1 $3758.4$ 829.78 5266.7GAP-13-C3AP4594/GAP209	GAP-3-C	AP <sub>52%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>10%</sub>	2619.3	1590.4	5/8/.9	29.77	267.3
GAP-4-CAP $_{47\%}/GAP_{20\%}/A1_{18\%}/C_{15\%}$ 2623.61593.63802.529.76267.7GAP-5-CAP $_{42\%}/GAP_{20\%}/A1_{18\%}/C_{20\%}$ 2627.91596.7 $\frac{3816.9}{7}$ 29.75268.2GAP-6-CAP $_{37\%}/GAP_{20\%}/A1_{18\%}/C_{30\%}$ 2632.11599.7 $\frac{7}{7}$ 2268.6GAP-7-CAP $_{32\%}/GAP_{20\%}/A1_{18\%}/C_{30\%}$ 2636.21602.6 $\frac{384.6}{8}$ 29.74269.0GAP-8-CAP $_{27\%}/GAP_{20\%}/A1_{18\%}/C_{30\%}$ 2640.11605.4 $\frac{7}{7}$ 29.74269.0GAP-9-CAP $_{22\%}/GAP_{20\%}/A1_{18\%}/C_{40\%}$ 2643.81608 $\frac{3884.2}{8}$ 29.72270.1GAP-10-CAP $_{17\%}/GAP_{20\%}/A1_{18\%}/C_{40\%}$ 2643.81610.1 $\frac{3884.2}{8}$ 29.72270.4GAP-11-CAP $_{17\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2640.11611.6 $\frac{3884.2}{1}$ 29.72270.4GAP-11-CAP $_{12\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2650.21611.8 $\frac{3884.2}{1}$ 29.72270.4GAP-13-CGAP_{20\%}/A1_{18\%}/C_{55\%}2650.21611.8 $\frac{3884.2}{8}$ 29.72270.4GAP-13-CAP $_{57\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2650.21611.8 $\frac{385.4}{8}$ 29.72270.4GAP-13-CGAP_{20\%}/A1_{18\%}/C_{625\%}2650.21611.8 $\frac{385.9}{8}$ 29.72270.4GAP-13-CAP $_{57\%}/GAP_{20\%}/A1_{18\%}/C_{55\%}$ 2610.61584.1 $\frac{375.8}{8}$ 29.72270.4GAP-13-CAP $_{57\%}/GAP_{20\%}/A1_{18\%}/C_{52\%}$ 2617.61588.1					4	1	
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	GAP-4-C	$\Delta \mathbf{P}_{\rm res}/\mathbf{G} \Delta \mathbf{P}_{\rm res}/\Delta 1_{\rm res}/\mathbf{C}_{\rm res}$	2623.6	1503.6	3802.5	29.76	267.7
GAP-5-CAP $_{42\%}/GAP_{20\%}/A1_{18\%}/C_{20\%}$ 2627.91596.7 $\begin{array}{c} 3816.9\\7\\7\\7\\2\end{array}$ 20.75268.2GAP-6-CAP $_{37\%}/GAP_{20\%}/A1_{18\%}/C_{25\%}$ 2632.11599.7 $\begin{array}{c} 7\\7\\7\\7\\2\end{array}$ 268.6GAP-7-CAP $_{32\%}/GAP_{20\%}/A1_{18\%}/C_{30\%}$ 2636.21602.6 $\begin{array}{c} 3844.6\\8\\7\\7\\7\\7\\7\\7\\2\end{array}$ 29.74269.0GAP-8-CAP $_{27\%}/GAP_{20\%}/A1_{18\%}/C_{35\%}$ 2640.11605.4 $\begin{array}{c} 3857.4\\7\\7\\7\\7\\7\\7\\7\\7\\7\\7\\7<7<7<7<7<7<7<7<7<$	0/11-+-0	1 4 4/% O1 4 20% 7 418% C15%	2025.0	1575.0	5	5	207.7
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			2(27.0	1506 7	3816.9	29.75	260.2
GAP-6-CAP379%/GAP209%/A1189%/C25% 22632.11599.7 $3831.0$ 7 $29.75$ 2268.6GAP-7-CAP325%/GAP209%/A1189%/C30% 200%/A1189%/C35%2636.21602.6 $3844.6$ 829.74 6269.0GAP-8-CAP279%/GAP209%/A1189%/C35% 200%/A189%/C40%2643.81608 $386.9$ 829.73 4269.8GAP-9-CAP229%/GAP209%/A1189%/C40% 209%/A189%/C45%2643.81608 $3868.9$ 829.72 4269.8GAP-10-CAP179%/GAP209%/A1189%/C45% 200%/A189%/C45%2647.11610.1 $3878.3$ 829.72 8270.1GAP-11-CAP179%/GAP209%/A189%/C55% 200%/A189%/C62%2649.61611.6 $3884.2$ 829.72 2270.4GAP-12-CAP79%/GAP209%/A189%/C62% 2035.32635.31607.7 $66$ 92268.9GAP-13-CGAP209%/A189%/C52% 235%2610.61584.1 $378.4$ 829.72 9266.4GAP-13-CAP529%/GAP209%/A189%/JY- 235%2617.61588.1 $378.9.2$ 629.92 6267.1GAP-3-JY-23AP529%/GAP209%/A189%/JY- 2319%2631.61592 53820.47 7267.8GAP-4-JY-23AP529%/GAP209%/A189%/JY- 2319%2631.615963851.930.02 30.64268.5GAP-5-JY-23AP429%/GAP209%/A189%/JY- 2329%2631.61600 $3883.9$ 30.35269.2GAP-6-JY-23AP39%/GAP209%/A189%/JY- 2329%2635.61600 $3949.4$ 30.642 3GAP-6-JY	GAP-5-C	AP <sub>42%</sub> /GAP <sub>20%</sub> /AI <sub>18%</sub> /C <sub>20%</sub>	2627.9	1596.7	7	8	268.2
GAP-6-CAP37%/GAP20%/Al18%/C25% 22632.11599.7 $30.76$ 7 $21.77$ 2268.6GAP-7-CAP32%/GAP20%/Al18%/C30% 20%/Al8%/C35%2636.21602.6 $3844.6$ 29.74 6269.0GAP-8-CAP27%/GAP20%/Al18%/C35% 20%/Al8%/C35%2640.11605.4 $3857.4$ 729.74269.4GAP-9-CAP22%/GAP20%/Al18%/C40% 20%/Al8%/C45%2643.81608 $3868.9$ 829.73 4269.8GAP-10-CAP17%/GAP20%/Al18%/C45% 20%/Al8%/C35%2647.11610.1 $3878.3$ 829.72 8270.1GAP-11-CAP17%/GAP20%/Al18%/C55% 20%/Al18%/C62%2649.61611.6 $3884.2$ 829.72 8270.4GAP-12-CAP7%/GAP20%/Al18%/C62% 20%/Al18%/C62%2650.21611.8 $3865.9$ 829.72 8266.8GAP-13-CGAP20%/Al18%/C62% 235%2610.61584.1 $3758.4$ 829.78 5266.4GAP-13-CAP62%/GAP20%/Al18%/C42% 235%2617.61588.1 $378.2$ 829.72 5266.4GAP-2-JY-23AP5%/GAP20%/Al18%/JY- 235%2617.61588.1 $378.2$ 829.72 9267.1GAP-4-JY-23AP42%/GAP20%/Al18%/JY- 2315%2631.61592 $3820.4$ 7 $30.06$ 7267.8GAP-4-JY-23AP42%/GAP20%/Al18%/JY- 2325%2635.61600 $3883.9$ 30.35 30.35 30.35269.2GAP-5-JY-23AP3%/GAP20%/Al18%/JY- 2325%2645.61604291.64 3016.420.77 30.64 30.64<					3831.0	29.75	
GAP-7-CAP_{32\%}/GAP_{20\%}/Al_{18\%}/C_{30\%}2636.21602.6 $384.4.8$ $29.74$ 269.0GAP-8-CAP_27\%/GAP_20\%/Al_{18\%}/C_{35\%}2640.11605.4 $77$ $29.74$ 269.4GAP-9-CAP_22\%/GAP_20\%/Al_{18\%}/C_{40\%}2643.81608 $88$ $4$ 269.8GAP-10-CAP_17\%/GAP_20\%/Al_{18\%}/C_{45\%}2647.11610.1 $3857.4$ $29.72$ $270.1$ GAP-10-CAP_17\%/GAP_20\%/Al_{18\%}/C_{50\%}2649.61611.6 $3884.2$ $29.72$ $270.1$ GAP-11-CAP_12\%/GAP_20\%/Al_{18\%}/C_{50\%}2649.61611.6 $3884.2$ $29.72$ $270.4$ GAP-12-CAP_7%/GAP_20\%/Al_{18\%}/C_{55\%}2650.21611.8 $3884.2$ $29.72$ $270.4$ GAP-13-CGAP_20\%/Al_{18\%}/C_{62\%}2635.31607.7 $6$ $9$ $268.9$ GAP-13-CGAP_20\%/Al_{18\%}/C_{62\%}2610.61584.1 $375.4$ $29.78$ $266.4$ GAP-13-CAP_52\%/GAP_20\%/Al_{18\%}/C_{52\%}2610.61584.1 $375.4$ $29.78$ $266.4$ GAP-2-JY-23AP_57\%/GAP_20\%/Al_{18\%}/JY- $23.5\%$ 2617.61588.1 $378.9.2$ $29.92$ $267.1$ GAP-4-JY-23AP_57\%/GAP_20\%/Al_{18\%}/JY- $23.5\%$ 2631.61592 $3820.4$ $70.6$ $7$ $267.8$ GAP-5-JY-23AP_42\%/GAP_20\%/Al_{18\%}/JY- $23.2\%$ $263.6$ 1600 $3883.9$ $30.35$ $269.2$ GAP-6-JY-23AP_32\%/GAP_20\%/Al_{18\%}/JY- $23.2\%$ $265.6$ 1604 $3949.4$ $30.64$ $270.7$ <td>GAP-6-C</td> <td>AP37%/GAP20%/Al18%/C25%</td> <td>2632.1</td> <td>1599.7</td> <td>7</td> <td>29.75</td> <td>268.6</td>	GAP-6-C	AP37%/GAP20%/Al18%/C25%	2632.1	1599.7	7	29.75	268.6
GAP-7-C $AP_{32\%}/GAP_{20\%}/AI_{18\%}/C_{30\%}$ 2636.21602.6 $3844.6$ 29.74269.0GAP-8-C $AP_{27\%}/GAP_{20\%}/AI_{18\%}/C_{35\%}$ 2640.11605.4 $\frac{3857.4}{7}$ 29.74269.4GAP-9-C $AP_{22\%}/GAP_{20\%}/AI_{18\%}/C_{40\%}$ 2643.81608 $\frac{3868.9}{8}$ 29.73269.8GAP-10-C $AP_{17\%}/GAP_{20\%}/AI_{18\%}/C_{45\%}$ 2647.11610.1 $\frac{3878.3}{8}$ 29.72270.1GAP-11-C $AP_{17\%}/GAP_{20\%}/AI_{18\%}/C_{50\%}$ 2649.61611.6 $\frac{3884.2}{8}$ 29.72270.4GAP-12-C $AP_{19\%}/GAP_{20\%}/AI_{18\%}/C_{55\%}$ 2650.21611.8 $\frac{3884.2}{1}$ 29.72270.4GAP-13-C $GAP_{20\%}/AI_{18\%}/C_{55\%}$ 2650.21611.8 $\frac{3884.2}{1}$ 29.72270.4GAP-13-C $AP_{79\%}/GAP_{20\%}/AI_{18\%}/C_{55\%}$ 2650.21611.8 $\frac{3758.4}{2}$ 29.72270.4GAP-13-C $GAP_{20\%}/AI_{18\%}/C_{62\%}$ 2635.31607.7 $\frac{3865.9}{6}$ 29.72268.9GAP-13-C $AP_{52\%}/GAP_{20\%}/AI_{18\%}/Y_{2}$ 2610.61584.1 $\frac{3758.4}{8}$ 29.72266.4GAP-13-C $AP_{52\%}/GAP_{20\%}/AI_{18\%}/Y_{2}$ 2617.61588.1 $\frac{3758.4}{6}$ 29.72266.4GAP-13-C $AP_{52\%}/GAP_{20\%}/AI_{18\%}/Y_{2}$ 2617.61588.1 $\frac{3758.4}{6}$ 29.72267.1GAP-2.1Y-23 $AP_{52\%}/GAP_{20\%}/AI_{18\%}/Y_{2}$ 2617.61588.1 $\frac{3758.4}{6}$ 20.06267.8GAP-3.1Y-23 $AP_{52\%}/GAP_{20\%}/AI_{18\%}/Y_{2}$ 263.6					/	2	
Index <th< td=""><td>GAP-7-C</td><td><math>AP_{32\%}/GAP_{20\%}/Al_{18\%}/C_{30\%}</math></td><td>2636.2</td><td>1602.6</td><td>3844.6</td><td>29.74</td><td>269.0</td></th<>	GAP-7-C	$AP_{32\%}/GAP_{20\%}/Al_{18\%}/C_{30\%}$	2636.2	1602.6	3844.6	29.74	269.0
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		5276 2076 1076 5076		1002.0	8	6	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	CADSC		2640.1	1605 4	3857.4	20.74	260.4
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	UAP-0-C	AF 27%/ GAF 20%/ AI 18%/ C35%	2040.1	1005.4	7	29.74	209.4
$\begin{array}{c c c c c c c c c c c c c c c c c c c $					3868.9	29.73	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	GAP-9-C	AP22%/GAP20%/Al18%/C40%	2643.8	1608	8	4	269.8
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $					2070.2	20.72	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	GAP-10-C	AP <sub>17%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>45%</sub>	2647.1	1610.1	30/0.3	29.72	270.1
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$					8	8	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	GAP-11-C	$AP_{120/}/GAP_{200/}/Al_{100/}/C_{500/}$	2649.6	1611.6	3884.2	29.72	270.4
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1 II 12% 01 II 20% 1 II 18% 050%	2019.0	1011.0	8	3	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	CAD 12 C	$AP_{7\%}\!/GAP_{20\%}\!/Al_{18\%}\!/C_{55\%}$	2650.2	1(11.0	3884.2	20.72	270 4
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	GAP-12-C		2650.2	1611.8	1	29.72	2/0.4
$\begin{array}{c c c c c c c c c c c c c c c c c c c $					3865.9	29.72	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	GAP-13-C	GAP <sub>20%</sub> /Al <sub>18%</sub> /C <sub>62%</sub>	2635.3	1607.7	6	0	268.9
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $					2759.4	20.79	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	GAP-1	AP <sub>62%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub>	2610.6	1584.1	3/38.4	29.78	266.4
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$					8	5	<u> </u>
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	GAP-2-IV-23	AP <sub>57%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY-	2617.6	1588 1	3789.2	29.92	267.1
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	0/11 2 01 23	23 <sub>5%</sub>	2017.0	1500.1	6	6	207.1
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		AP <sub>52%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY-	2624.6	1.500	2020 4	30.06	267.0
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	GAP-3-JY-23	2310%	2624.6	1592	3820.4	7	267.8
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		$AP_{470}/GAP_{200}/Al_{180}/JY$ -			3851.9	30.20	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	GAP-4-JY-23	23	2631.6	1596	5	0	268.5
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		$\frac{2315\%}{100}$			2002.0	20.25	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	GAP-5-JY-23	AP <sub>42%</sub> /GAP <sub>20%</sub> /AI <sub>18%</sub> /JY-	2638.6	1600	3883.9	30.35	269.2
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$		2320%			4	2	<u> </u>
GAP-7-JY-23 $23_{25\%}$ $2043.0$ $1004$ $2$ $7$ $207.0$ GAP-7-JY-23 $AP_{32\%}/GAP_{20\%}/Al_{18\%}/JY 2652.6$ $1608$ $3949.4$ $30.64$ $270.7$	GAP-6-JY-23	AP <sub>37%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY-	2645.6	1604	3916.4	30.49	267.0
GAP-7-JY-23         AP <sub>32%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY- 2330%         2652.6         1608         3949.4         30.64         270.7		23 <sub>25%</sub>	2043.0	1007	2	7	
$\begin{vmatrix} GAP-/-JY-23 \\ 23_{30\%} \end{vmatrix} = \begin{vmatrix} 2652.6 \\ 4 \end{vmatrix} = \begin{vmatrix} 1608 \\ 4 \end{vmatrix} = \begin{vmatrix} 270.7 \\ 3 \end{vmatrix}$	GAP-7-JY-23	AP <sub>32%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY-	0.000	1608	3949.4	30.64	270.7
		2330%	2652.6		4	3	

GAP-8-JY-23	AP <sub>27%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY- 23 <sub>35%</sub>	2659.7	1612	3983.0 1	30.79 2	271.4
GAP-9-JY-23	AP <sub>22%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY- 23 <sub>40%</sub>	2666.8	1616.1	4017.0 9	30.94 3	272.1
GAP-10-JY- 23	AP <sub>17%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY- 23 <sub>45%</sub>	2673.9	1620	4051.6 1	31.09 9	272.8
GAP-11-JY- 23	AP <sub>12%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY- 23 <sub>50%</sub>	2681.1	1623.9	4086.3 8	31.26 1	273.6
GAP-12-JY- 23	AP <sub>7%</sub> /GAP <sub>20%</sub> /Al <sub>18%</sub> /JY- 23 <sub>55%</sub>	2688.3	1627.7	4121.0 6	31.42 8	274.3
GAP-13-JY- 23	GAP <sub>20%</sub> /Al <sub>18%</sub> /JY-23 <sub>62%</sub>	2697.9	1632.4	4168.4 7	31.67 4	275.3
Codes	Propellant formulas	I <sub>sp</sub> /(N s/kg)	C*/(m/ s)	T <sub>c</sub> /K	M <sub>e</sub>	Isp/( s)
HTPB-1	AP <sub>68%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub>	2601.9	1589	3383.4 1	25.88 9	265.5
HTPB-2-A	AP <sub>63%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /A <sub>5%</sub>	2606.9	1592	3402.2 8	25.98	266.0
НТРВ-3-А	AP58%/HTPB14%/Al18%/A10%	2611.6	1594.5	3419.5 1	26.07 1	266.5
HTPB-4-A	AP53%/HTPB14%/Al18%/A15%	2615.7	1596.5	3434.7 5	26.16 3	266.9
HTPB-5-A	AP48%/HTPB14%/Al18%/A20%	2618.7	1597.8	3447.5 5	26.25 5	267.2
HTPB-6-A	AP43%/HTPB14%/Al18%/A25%	2619.6	1598.3	3457.3 6	26.35 2	267.3
HTPB-7-A	AP <sub>38%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /A <sub>30%</sub>	2616.3	1597.8	3463.4 3	26.47 3	267.0
HTPB-8-A	AP33%/HTPB14%/Al18%/A35%	2609.3	1596.1	3464.6 1	26.60 1	266.3
HTPB-9-A	AP28%/HTPB14%/Al18%/A40%	2599.5	1592.9	3458.9 6	26.71 9	265.3
HTPB-10-A	AP23%/HTPB14%/Al18%/A45%	2586.7	1587.2	3443.2 2	26.83 2	263.9
HTPB-11-A	AP <sub>18%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /A <sub>50%</sub>	2570.1	1577.2	3412.6 9	26.93 2	262.3
HTPB-12-A	AP <sub>13%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /A <sub>55%</sub>	2553.3	1561.6	3363.3 1	27.00 9	260.5
HTPB-13-A	AP8%/HTPB14%/Al18%/A60%	2537.2	1541	3295.1 7	27.08 5	258.9
HTPB-14-A	HTPB <sub>14%</sub> /Al <sub>18%</sub> /A <sub>68%</sub>	2514.4	1502.9	3158.1	27.20 9	256.6
HTPB-1	AP <sub>68%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub>	2601.9	1589	3383.4	25.88	265.5

			1			
				1	9	
HTDR 2 B	AP <sub>63%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /B <sub>5%</sub>	2605.2	1501	3403.0	26.01	265.8
IIII D-2-D			1571	7	3	205.0
		• • • • •	1	3421.7	26.13	
НТРВ-3-В	$AP_{58\%}/HTPB_{14\%}/AI_{18\%}/B_{10\%}$	2608.3	1592.6	6	8	266.2
				3439.2	26.26	
HTPB-4-B	AP <sub>53%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /B <sub>15%</sub>	2611	1593.9	0	1	266.4
				2455 4	26.20	
HTPB-5-B	AP <sub>48%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /B <sub>20%</sub>	2613.1	1594.8	3433.4	20.39	266.6
				3	1	
HTPB-6-B	AP429//HTPB149//Al189//B250/	2614-3	1595 3	3469.8	26.51	266.8
			10,000	6	9	
UTDD 7 D		2612 7	1505 1	3482.1	26.65	2667
ПІГ <b>D-</b> /-D	$AF_{38\%}/\Pi FD_{14\%}/AI_{18\%}/D_{30\%}$	2015.7	1393.1	2	3	200.7
				3491.5	26.80	
HTPB-8-B	AP <sub>33%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /B <sub>35%</sub>	2610	1594.2	2	4	266.3
				3496.9	26.96	
HTPB-9-B	AP <sub>28%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /B <sub>40%</sub>	2603.7	1592.3	1	1	265.7
				2406.4	27.11	
HTPB-10-B	AP23%/HTPB14%/Al18%/B45%	2595	1589.1	3496.4	27.11	264.8
				1	2	
HTPB-11-B	$AP_{180/}/HTPB_{140/}/Al_{180/}/B_{500/}$	2583 5	1583 5	3486.7	27.26	263.6
			1000.0	5	4	205.0
		2566.2	1574	3463.7	27.40	261.0
ПІРВ-12-В	AP <sub>13%</sub> /HTPB <sub>14%</sub> /AI <sub>18%</sub> /B <sub>55%</sub>	2300.5	13/4	4	9	201.9
				3424.2	27.52	
HTPB-13-B	AP <sub>8%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /B <sub>60%</sub>	2547.9	1559.7	8	3	260.0
				3328.8		
HTPB-14-B	$HTPB_{14\%}/Al_{18\%}/B_{68\%}$	2519.7	1529.2	5	27.71	257.1
				22024	25.00	
HTPB-1	AP68%/HTPB14%/Al18%	2601.9	1589	3383.4	25.88	265.5
				1	9	
НТРВ-2-С	$AP_{629/}/HTPB_{149/}/Al_{199/}/C_{59/}$	2604.1	1590.4	3386.1	25.88	265.7
			4			
HTDR 3 C	Δ D/HTDB/Δ1/C	2606	1501.3	3386.8	25.87	265.0
IIII D-5-C	$A_{158\%}/1111D_{14\%}/A_{18\%}/C_{10\%}$	2000	1391.5	2	1	205.9
			1.501.5	3384.7	25.86	2.00
НТРВ-4-С	$AP_{53\%}/HTPB_{14\%}/AI_{18\%}/C_{15\%}$	2607.2	1591.5	9	2	266.0
				3379.2	25.85	
HTPB-5-C	AP48%/HTPB14%/Al18%/C20%	2607.1	1590.8	4	4	266.0
				2260.1		
HTPB-6-C	AP <sub>43%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>25%</sub>	2603.4	1588.8	3309.1	25.86	265.7
				2		
HTPB-7-C	AP <sub>38%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>20%</sub>	2592.6	1585.1	3353.0	25.91	264.6
	2 m 38% mm D 14% 2 m 8% C 30%			9	3	_
HTPR-8-C	$\Delta P_{aaa}/HTPB_{aaa}/\Lambda 1_{aaa}/C$	2577 1	1570 /	3320.3	25.96	263.0
11110-0-0	$\begin{bmatrix} 2 11 33\% 1111 D_{1}4\% A1_{1}8\% C_{3}5\% \\ \end{bmatrix}$	2377.1	15/9.4	5529.5	3	205.0

НТРВ-9-С	AP <sub>28%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>40%</sub>	2557.9	1571.2	3294.8 1	26.01	261.0
НТРВ-10-С	AP23%/HTPB14%/Al18%/C45%	2538.4	1558.9	3244.2 5	25.95 7	259.0
HTPB-11-C	AP <sub>18%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>50%</sub>	2522.1	1539.3	3170.1 2	25.91 5	257.4
HTPB-12-C	AP <sub>13%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>55%</sub>	2509.8	1513.4	3072.6 1	25.88 4	256.1
НТРВ-13-С	AP <sub>8%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>60%</sub>	2501.8	1504	2968.3 4	25.86 1	255.3
HTPB-14-C	HTPB <sub>14%</sub> /Al <sub>18%</sub> /C <sub>68%</sub>	2493.9	1495.1	2946.4 2	25.82 9	254.5
HTPB-1	AP <sub>68%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub>	2601.9	1589	3383.4 1	25.88 9	265.5
HTPB-2-JY- 23	AP <sub>63%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>5%</sub>	2608.6	1593	3409.0 7	26.00 8	266.2
HTPB-3-JY- 23	AP <sub>58%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>10%</sub>	2615	1596.7	3433.5 5	26.12 7	266.8
HTPB-4-JY- 23	AP <sub>53%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>15%</sub>	2621	1600	3456.6 9	26.24 7	267.4
HTPB-5-JY- 23	AP <sub>48%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>20%</sub>	2626.2	1602.8	3478.3	26.36 7	268.0
НТРВ-6-ЈҮ- 23	AP <sub>43%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>25%</sub>	2630.3	1605.1	3498.1	26.48 9	268.4
HTPB-7-JY- 23	AP <sub>38%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>30%</sub>	2632.5	1606.8	3515.6 9	26.61 7	268.6
НТРВ-8-ЈҮ- 23	AP <sub>33%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>35%</sub>	2631.9	1607.8	3530.4 2	26.76 3	268.6
НТРВ-9-ЈҮ- 23	AP <sub>28%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>40%</sub>	2629	1607.9	3541.2 1	26.91 2	268.3
HTPB-10-JY- 23	AP <sub>23%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>45%</sub>	2624	1606.6	3546.2 9	27.05	267.8
HTPB-11-JY- 23	AP <sub>18%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>50%</sub>	2615.9	1603.1	3542.9 8	27.20 2	266.9
HTPB-12-JY- 23	AP <sub>13%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>55%</sub>	2600.9	1596.2	3528.1 7	27.34	265.4
HTPB-13-JY- 23	AP <sub>8%</sub> /HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY- 23 <sub>60%</sub>	2584.1	1585.2	3499.7 5	27.44 7	263.7
HTPB-14-JY- 23	HTPB <sub>14%</sub> /Al <sub>18%</sub> /JY-23 <sub>68%</sub>	2558.3	1560.9	3426.9 7	27.62 4	261.1

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