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Determination of Autogenous Ignition Temperature of Isopropyl Alcohol and Ethanol

The NESC performed tests to measure the autogenous ignition temperature (AIT) of isopropyl alcohol (IPA) and ethanol in a pressurized, pure oxygen environment. The available data were for lower pressures than required and the majority of the data were for air rather than oxygen. Test results showed the average AITs for IPA in gaseous oxygen at 10.3 megapascals (MPa) (1,500 psi) and 15.2 MPa (2,200 psi) were 199.3 degrees Celsius (°C) (390.8 degrees Fahrenheit (°F)) and 201.6°C (394.8°F), respectively. The average AITs for ethanol in gaseous oxygen at 10.3 MPa (1,500 psi) and 15.2 MPa (2,200 psi) were 193.2°C (379.8°F) and 198.2°C (388.8°F), respectively.

Background

A request was recently made to NASA to provide the autogenous ignition temperature (AIT) of isopropyl alcohol (IPA) in a pressurized, pure oxygen environment. NASA provided the available data, but there was significant variability between data sources. The available data were for much lower pressures than required, and the majority of the data were for air rather than oxygen. The scatter seen in previous tests was likely due to test configuration and experimental technique differences, as well as inherent variability in the AIT response itself. NASA was requested to experimentally determine the AIT of both IPA and ethanol, both of which are extensively applied as cleaners and solvents in propulsion systems.

Test Procedures

The AIT testing of IPA and ethanol was performed at White Sands Test Facility (WSTF) for pressures representative of those found in spacecraft and launch vehicle propulsion systems. The WSTF standard test method was performed as follows. A sample holding assembly, contained within a reaction vessel pressurized with 100% oxygen to the required test pressure, was heated in an electric furnace at a rate of 5 ± 1°C (9 ± 1°F)/min from 60 to 260°C (140 to 500°F). Heating of the vessel was continued at an uncontrolled rate to a maximum temperature of 450 °C (842°F). Temperatures were monitored as a function of time by means of a thermocouple and data acquisition system. During testing, pressure was monitored but not maintained. Ignition of the test sample was indicated by a rapid temperature rise of at least 20°C (36°F) and was confirmed post-test by the destruction of the sample.

The tests used Sigma-Aldrich anhydrous 2-propanol (IPA), part number 278475, 99.5% purity, and Sigma-Aldrich ethyl alcohol (ethanol), pure, part number 459844, minimum 99.5% purity, American Chemical Society reagent. Both the IPA and ethanol were used as received without further purification. Testing was performed for the IPA and the ethanol at both 10.3 MPa (1,500 psi) and 15.2 MPa (2,200 psi). Five tests were run at each pressure using ~200 mg each of the IPA and ethanol. An additional test was run using 500 mg of IPA at 1,500 psi.

Results

The results are tabulated in Tables 1 and 2.

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Sample Number	Test Pressure		Sample Weight	AIT		Pressure at Ignition		Δ Temp Rise on Ignition		Δ Press Rise on Ignition	
	MPa	(psia)	g	°C	(°F)	MPa	(psia)	°C	(°F)	MPa	(psia)
1	10	1500	0.217	196	385	16	2393	81	145	4	545
2			0.22	198	388	16	2354	111	200	3	468
3			0.225	203	397	17	2400	124	223	3	418
4			0.222	189	373	15	2247	105	189	5	702
5			0.213	211	411	16	2384	56	101	3	405
Average			0.2194	199.3	390.8	16.2	2355.6	95.3	171.6	3.5	507.6
1	10	1500	0.521	208	407	17	2424	311	559	14	1979
1	15	2200	0.221	202	396	24	3445	144	259	5	706
2			0.22	194	381	24	3526	88	159	4	595
3			0.218	201	394	19	2753	89	161	4	645
4			0.212	205	401	25	3664	77	138	4	629
5			0.226	206	402	24	3435	106	191	6	933
Average			0.2194	201.6	394.8	23.2	3364.6	100.9	181.6	4.8	701.6

Table 1. Autogenous ignition temperatures for IPA.

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Sample Number	Test Pressure		Sample Weight	AIT		Pressure at Ignition		Δ Temp Rise on Ignition		Δ Press Rise on Ignition	
	MPa	(psia)	g	°C	(°F)	MPa	(psia)	°C	(°F)	MPa	(psia)
1	10	1500	0.224	184	364	15	2173	114	205	2	339
2			0.231	198	389	16	2336	102	183	2	324
3			0.224	204	400	17	2494	76	136	4	618
4			0.221	191	375	16	2366	97	175	3	448
5			0.223	188	371	16	2328	97	175	3	394
Average			0.2246	193.2	379.8	16.1	2339.4	97.1	174.8	2.9	424.6
1	15	2200	0.218	201	393	26	3717	64	115	4	634
2			0.216	202	396	24	3547	78	140	4	536
3			0.217	202	396	25	3621	67	121	4	621
4			0.218	200	392	25	3636	76	136	3	470
5			0.219	186	367	25	3615	81	146	5	653
Average			0.2176	198.2	388.8	25.0	3627.2	73.1	131.6	4.0	582.8

Table 2. Autogenous ignition temperatures for ethanol.

References

1. Dorney, D.; Harper, S.; Reys, I.; Wentzel, D.; McClure, M.; Juarez, A.: Determination of Autogenous Ignition Temperature for Isopropyl Alcohol and Ethanol. NASA/TM-2020-5004683.
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3. Wegener, W.; Binder, C.; Hengstenberg, P.; Herrmann, K.-P.; and Weinert, D.' "Tests to Evaluate the Suitability of Materials for Oxygen Service," Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres: Third Volume, ASTM STP 986, D. W. Schroll, Ed., ASTM, Philadelphia, 1988, pp. 268-278.

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