

Effect of High Pressure Hydrogen on the Volatiles in Polymers Buna-N and Viton



Introduction and Objective

The hydrogen economy requires storage and delivery of high pressure hydrogen, which experiences pressure and temperature fluctuations. Materials that can withstand these conditions are needed. In this work, samples of Buna-N and Viton A that had been exposed to high pressure (100 MPa) argon and hydrogen (ArH₂) and to helium and hydrogen (HeH₂). The inert gases had been used for leak checking. The exposed samples were compared to unexposed samples using thermal desorption spectroscopy (TDS). In TDS the temperature of a sample in vacuum can be ramped and held at constant while taking a series of mass spectra of the outgassed products. The temperature and pressure are also recorded. Our objective is to determine if high pressure hydrogen affects the outgassing of the polymers Buna-N and Viton. Properties such as strength and compression set are being measured by fellow researchers.*

Material Information

Material	Exposure	Before Wt.	After Wt.	% loss
Buna-N	Not Exposed	270.91 mg	248.62 mg	8.2%
Buna-N	Ar-H ₂	131.39 mg	120.84 mg	8.03%
Buna-N	He-H ₂	146.53 mg	133.98 mg	8.6%
Viton A	Not Exposed	305.62 mg	305.32 mg	0.1%
Viton A	Ar-H ₂	217.52 mg	217.17 mg	0.2%
Viton A	He-H ₂	189.72 mg	189.35 mg	0.2%

Buna-N is a polymer made up of 2-propenenitrile, 3(1,3-butadiene), and 1,2-butadiene. It is a nitrile rubber with a service temperature of ~138°C used in applications that take advantage of its oil, gasoline and solvent resistance.**

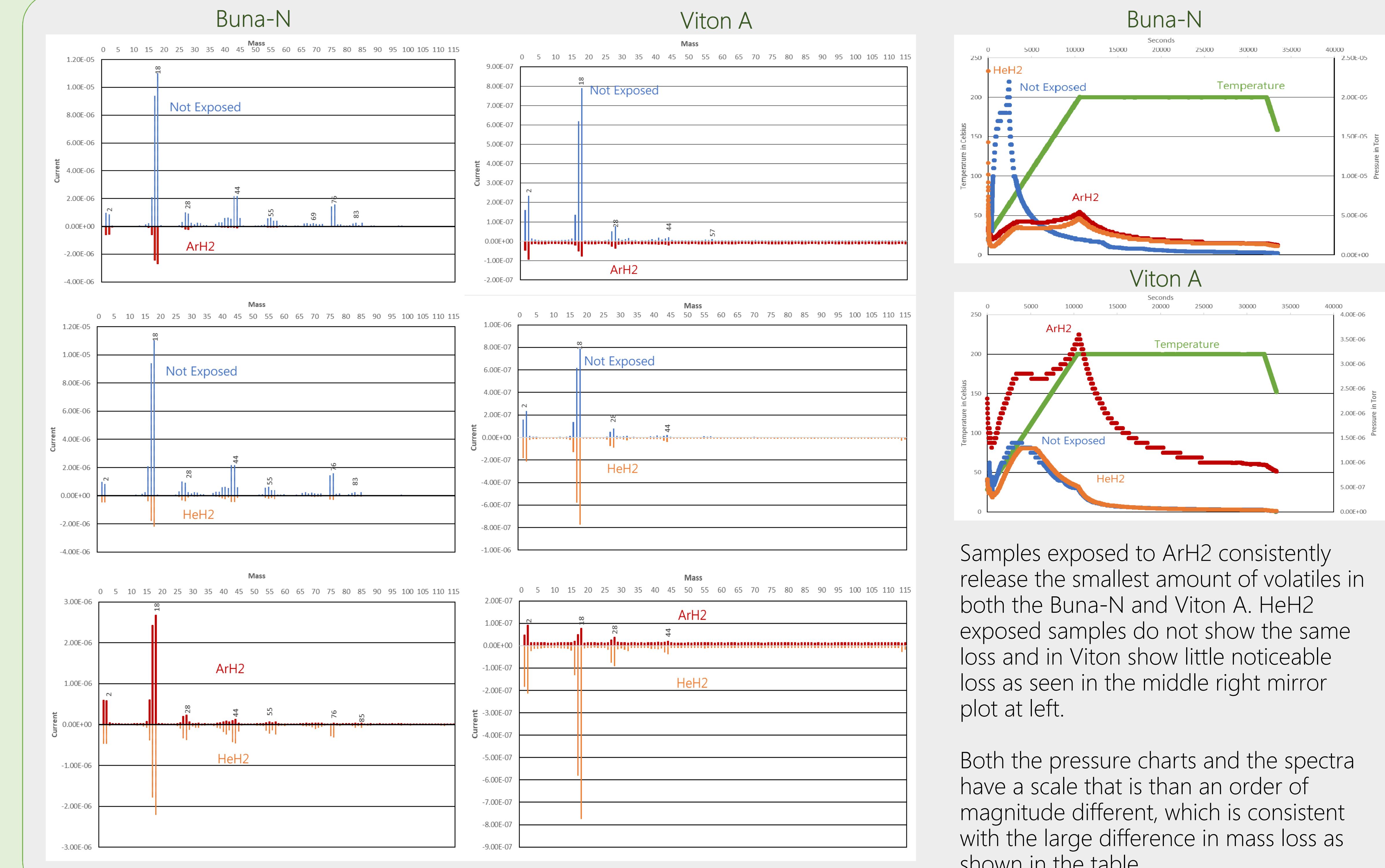
Viton A is a polymer made up of hexafluoropropylene and vinylidene fluoride. It is a fluorocarbon rubber with a service temperature of ~225 °C used in various seals such as in engines, fuel systems, chemical systems and high temperature environments.***

Experimental

For TDS, the samples were ramped at 1°C per minute to 200°C under vacuum and held at 200°C for three hours while recording temperature, pressure, and mass spectra.

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Results



The mass spectra are the maximum seen at each mass throughout the experiment, adjusted for the difference in weight for each polymer.

Samples exposed to ArH₂ consistently release the smallest amount of volatiles in both the Buna-N and Viton A. HeH₂ exposed samples do not show the same loss and in Viton show little noticeable loss as seen in the middle right mirror plot at left.

Both the pressure charts and the spectra have a scale that is than an order of magnitude different, which is consistent with the large difference in mass loss as shown in the table.

Conclusion

Although the percent weight loss difference between the exposed and unexposed samples is small, there is a large difference in the pressure during TDS suggesting that the different species have different sensitivity factors. There is also a significant quantitative difference in the mass spectra. For the Buna-N the exposed samples have significantly less volatiles than those not exposed. In Viton the mass signal is larger for the ArH₂ samples than for the HeH₂ samples. We can conclude that high pressure gas exposure has a demonstrable effect in removing some of the volatiles present within the samples.

In previous work, EPDM showed a much smaller mass loss (1.9 for non-exposed and 2.0% for Ar/H₂ exposed samples); but a similar high pressure difference between the two during TDS confirming the above effect of removing volatiles present in the samples upon exposure.

Future work should include a more detailed examination of the time/temperature evolution of the individual masses seen in this data. There are plans for similar experiments using hydrogen only as well as experiments where the high pressure hydrogen is cycled.

In previous work, did EPDM not show a massive pressure change as opposed to weight loss between exposed and unexposed. Maybe we can say: In previous work with EPDM, there was a similar effect with samples exposed to Ar/H₂ showing a significant increase in pressure compared to unexposed EPDM.
Menon, Nalini Chuliyil, 8/14/2017