



Filter Materials Decomposition Kinetics Study

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The estimated stability of HEPA media has been used to dictate HEPA filter shelf life; however, visual inspections of aged filters have shown damage to the gaskets or the polyurethane sealant of the filter pack instead of the media itself. Thermal decomposition profiles were performed for typical materials used as components of HEPA filters to establish material stability and to estimate the relative thermal endurance of these components. This study was based on ASTM methods ASTM E1641 and ASTM E1877. These methods use thermal decomposition shifts from different heating profiles to calculate the activation energy and estimate the stability, or thermal endurance, of the materials. The ASTM methods assume first order kinetics for the decomposition reactions, whereas the materials used may not adhere to first order kinetics. Additionally, the thermal endurance results for some materials are subject to variation based on manufacturing processes, additives, and preparation of the material. The results from these calculations can only be used in relation to each other to rank the components on terms of stability over time; therefore, ^[1]the results are useful for comparison of the components, but they do not represent the true stability of the material.

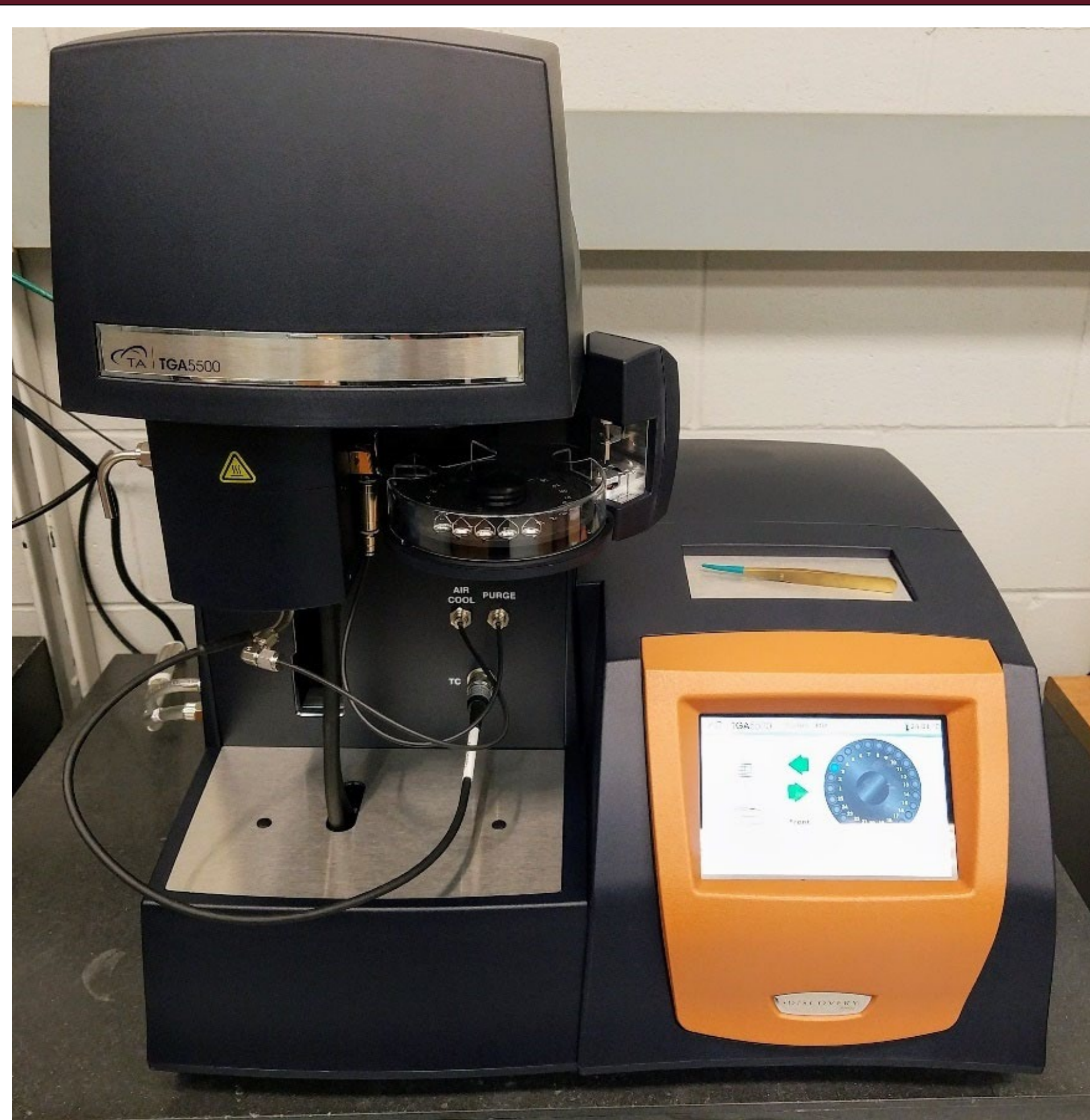
All decomposition kinetics material testing was performed on a TA Instruments, Incorporated, Discovery TGA 5500, using ICET's procedure HEPA-ATP-002, *Thermal Compositional Analysis Procedure*. The analysis method used was a ramp up procedure with equilibration at 30 °C and heating rates of 2.5, 5, 7, and 10 °C/min to 600 °C under a N₂ flowrate of 25 mL/min using high temperature platinum pans. Specimens displaying decomposition of species continuing past 600 °C had the temperature range extended to 675 or 700 °C, so the decomposition events could be completed.

The thermal endurance for each material was estimated at 23 and 60 °C. The temperatures were chosen based on conditions filters may see during storage, ambient conditions of 23 °C, and the maximum temperature for NQA-1 Level B storage of 60 °C. A lower thermal endurance corresponds to a lower material stability.

Results indicate that components other than the medium itself may degrade and provide a functional loss to the operation of the filter.

Seventeen materials were analyzed, including medium, gasket material (GAS), gasket seam/gasket adhesive material (GAD), gel seal material (GEL), and polyurethane sealant (PUR). Specimens identified with a "C" are control specimens.

Stability Rank	Specimen	Thermal Endurance at 23 °C (years) ^[1]	Thermal Endurance at 60 °C (years) ^[1]
1	M009 Media	9.19E+22	6.98E+16
2	M008 Media	5.53E+22	5.90E+16
3	M007 Media	4.56E+18	4.01E+13
4	A231 Media	7.70E+16	1.55E+12
5	A273R Media	4.79E+16	1.06E+12
6	A274-GEL	6.91E+14	4.61E+10
7	C006 Binder	1.73E+11	2.44E+07
8	A231-PUR	7.32E+08	2.32E+05
9	A273R-PUR	1.43E+08	7.19E+04
10	C004-GEL	3.36E+07	1.40E+05
11	C003-PUR	8.29E+05	1.47E+03
12	A231-GAD	3.04E+05	247
13	A273R-GAS	662	1.85
14	C002-GSE	470	3.83
15	C001-GAS	296	1.22
16	A231-GSE	22.6	0.182
17	A231-GAS	1.15	0.011



TGA 5500 Method

Apparatus	TA Instruments, Inc. Discovery TGA 5500
Temperature Range	30 to 700 °C
Purge Gas / Flowrate	N ₂ 99.99%, 25 mL/min
Preanalysis Purge Time	2 minutes
Number of Determinations at Each Heating Rate	3



References:
 Standard Test Method for Decomposition Kinetics by Thermogravimetry Using the Ozawa/Flynn/Wall Method, *ASTM International*, E1641-16, 2016.
 Standard Practice for Calculating Thermal Endurance of Materials from Thermogravimetric Decomposition Data, *ASTM International*, E1877-15, 2015.

Stability Rank	Material	Average Thermal Endurance at 23 °C (years) ^[1]	Average Thermal Endurance at 60 °C (years) ^[1]
1	Medium	2.94E+22	2.58E+16
2	Gel Seal	3.46E+14	2.31E+10
3	Polyurethane	2.92E+08	1.02E+05
4	Gasket Seam/ Gasket Adhesive	1.02E+05	83.6
5	Gasket	320	1.04

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