



# Stabilization of Flame Retardant High Temperature Resin Systems

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*Kemgard*<sup>®</sup> products are inorganic flame retardant/smoke suppressant additives based on patented surface treatment technology. The *Kemgard*<sup>®</sup> product chemistries include zinc molybdate, calcium zinc molybdate and zinc oxide/phosphate complexes.

*Kemgard*<sup>®</sup> products are used in a wide range of polymer applications, including PVC, nylon, rubber, polyester, epoxy, and polyolefins



# Kemgard and Char Formation

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- Promote formation of Char
  - Enhanced thermal stability of char
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- ***Reduced mass of volatiles. Less material to burn.***
  - ***Thermal insulation. Char functions as a thermal barrier reducing the heat flux reaching the virgin polymer.***
  - ***Obstruction of combustible gases.***



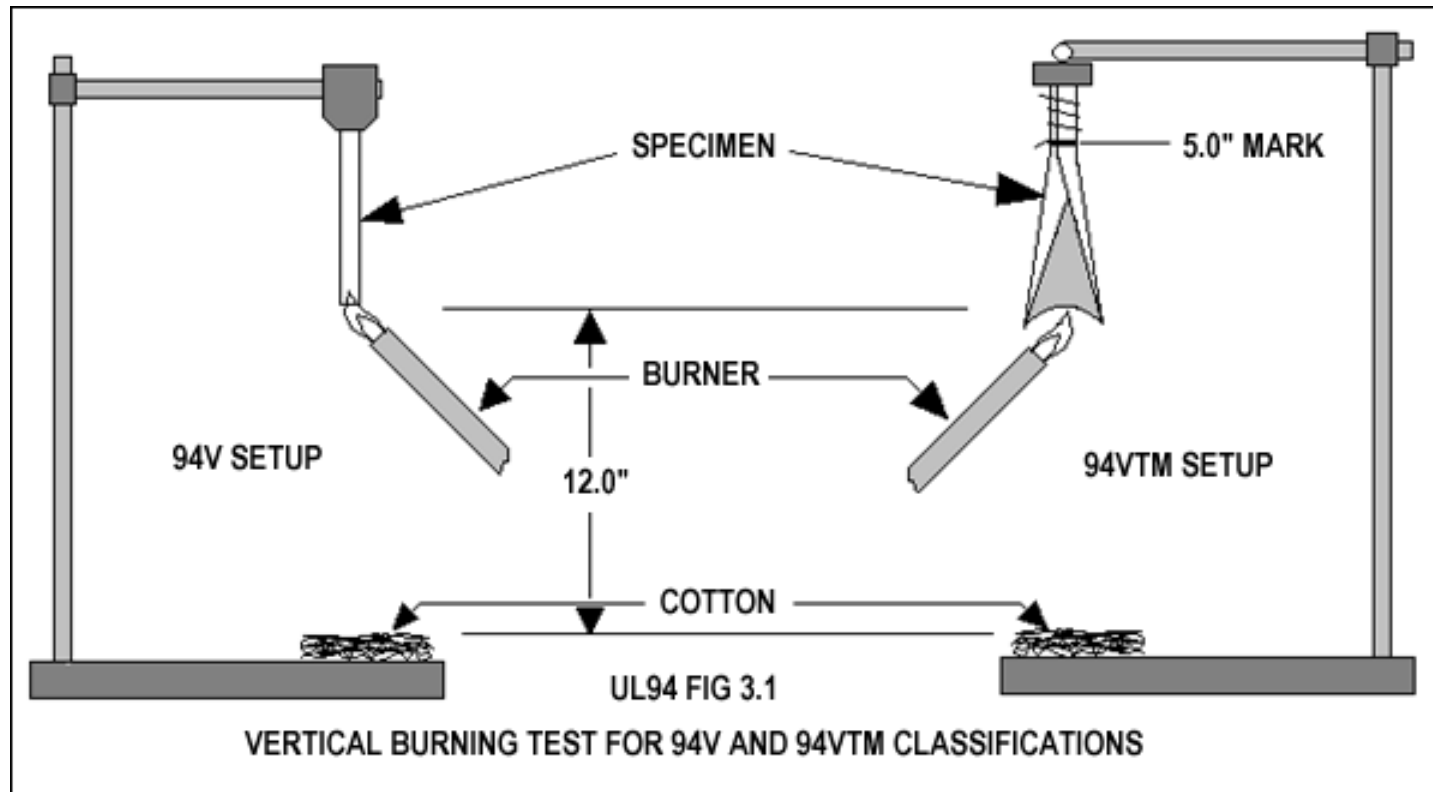
# Glass Filled Nylon 6/6

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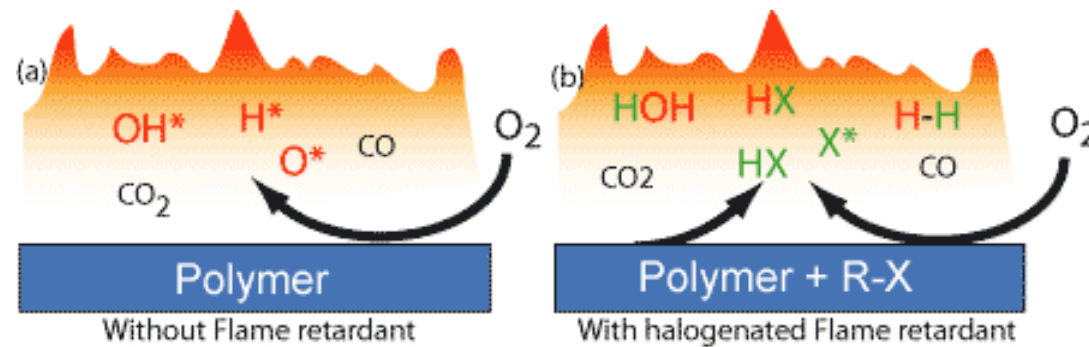
- Abrasion, Heat Resistance, High Modulus, Dimensional Stability
- Electrical and Electronic Application
  - FR Requirements – UL94



# UL-94 Test



# Halogen/Antimony Synergy





# Halogen/Antimony

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- Impacts Thermal Stability of Nylon 6/6
  - Limits Molding Temperature
  - Can increase Mold Corrosion
  - Can affect electrical properties (CTI)
  - Can affect physical properties



# Kemgard 981/981N

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Zinc Oxide/Zinc Phosphate Complex

<b>Typical Properties</b>	<b>KG 981</b>	<b>KG 981N</b>
% Zn	69.4	73.5
% Moisture	0.2	0.1
Oil Absorption g/100 g	13.1	10
Average Particle Size (microns)	5.8	2.1



# Experimental Design

	1	2	3	4	5	6	7
<b>Zytel Nylon 70G33</b>	<b>76.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>
<b>Pyrochek 68PB**</b>	<b>23.5</b>	<b>23.5</b>	<b>23.5</b>	<b>23.5</b>			
<b>Saytex 7010**</b>					<b>23.5</b>	<b>23.5</b>	<b>23.5</b>
<b>Antimony Oxide</b>		<b>7</b>	<b>5</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>5</b>
<b>KG 981</b>			<b>2</b>			<b>2</b>	
<b>KG 981-N</b>				<b>2</b>			<b>2</b>

\* DuPont

\*\* Albemarle



# Molded Samples

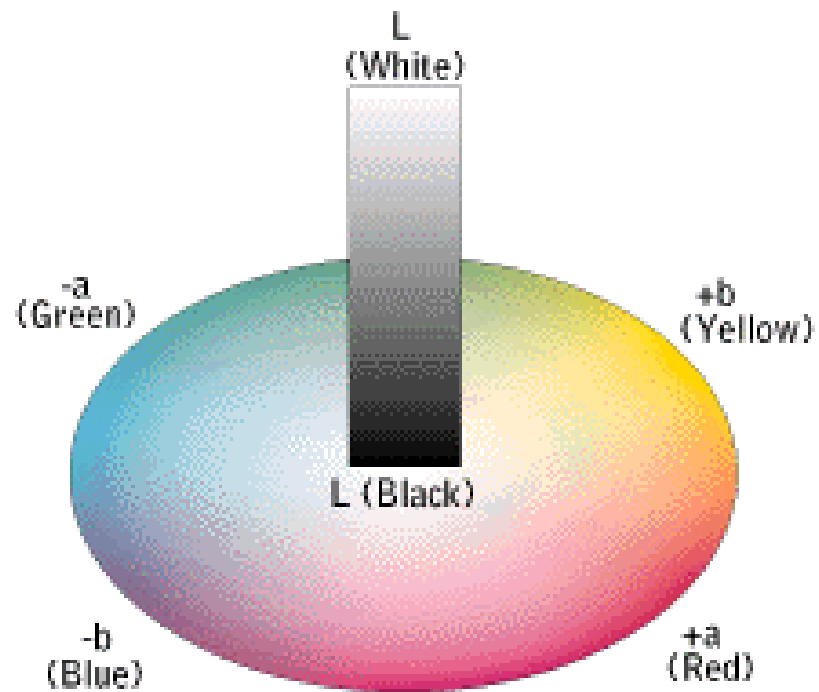
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# L\*a\*b Color Scale

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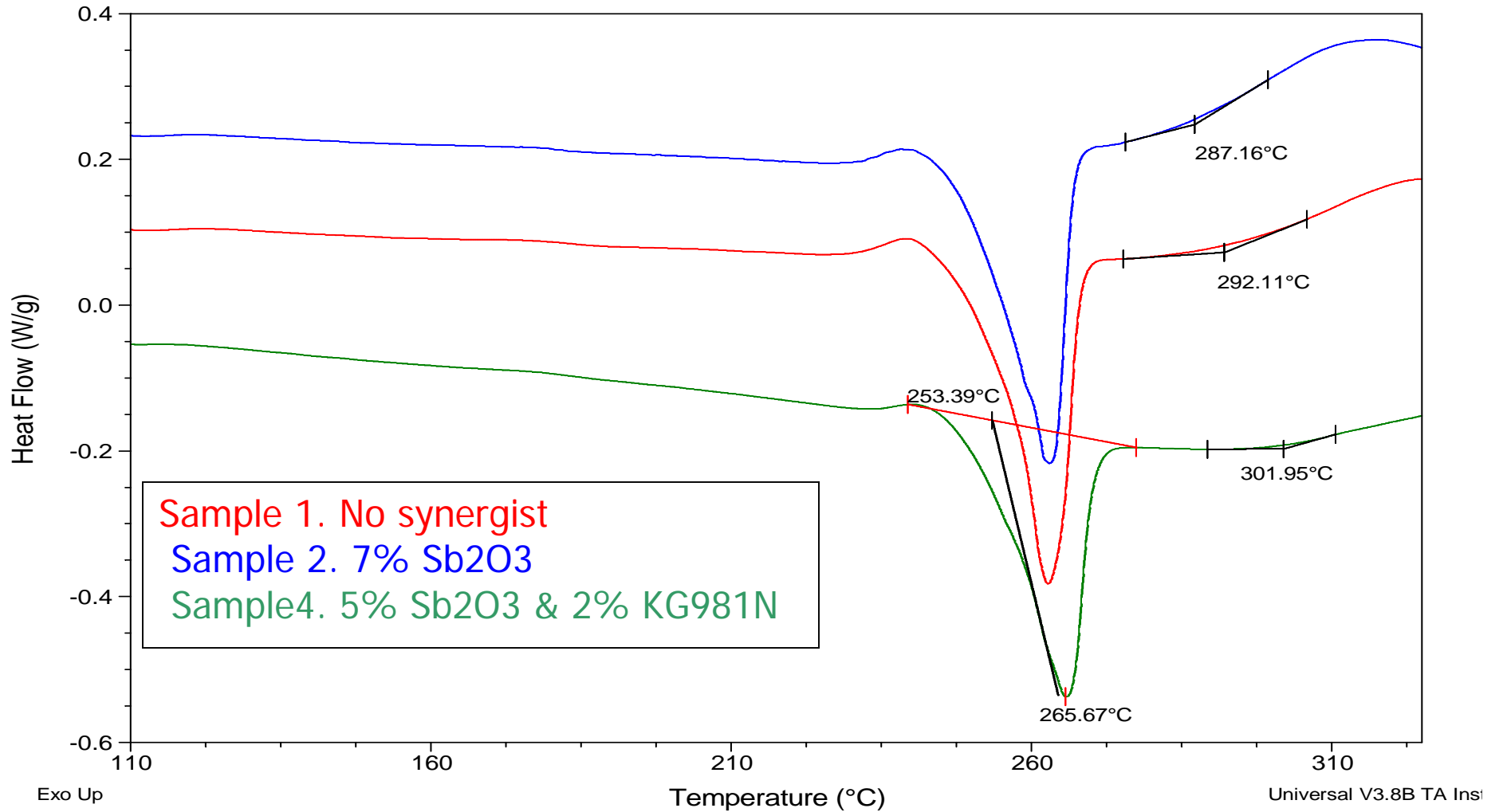




# Color Measurements

	1	2	3	4	5	6	7
<b>Zytel Nylon</b>	<b>76.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>	<b>69.5</b>
<b>Pyrochek 68PB</b>	<b>23.5</b>	<b>23.5</b>	<b>23.5</b>	<b>23.5</b>			
<b>Saytex 7010</b>					<b>23.5</b>	<b>23.5</b>	<b>23.5</b>
<b>Antimony Oxide</b>		<b>7</b>	<b>5</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>5</b>
<b>KG 981</b>			<b>2</b>			<b>2</b>	
<b>KG 981-N</b>				<b>2</b>			<b>2</b>
<b>Color Values</b>							
<b>L*</b>	<b>63.65</b>	<b>67.07</b>	<b>69.86</b>	<b>74.29</b>	<b>78.32</b>	<b>79.99</b>	<b>80.45</b>
<b>a*</b>	<b>3.03</b>	<b>1.86</b>	<b>1.87</b>	<b>1.72</b>	<b>0.94</b>	<b>1.24</b>	<b>0.97</b>
<b>b*</b>	<b>20.93</b>	<b>15.28</b>	<b>15.12</b>	<b>14.53</b>	<b>14.19</b>	<b>14.16</b>	<b>13.97</b>

# Differential Scanning Calorimetry Nylon 6/6 w. Pyrochek 68PB





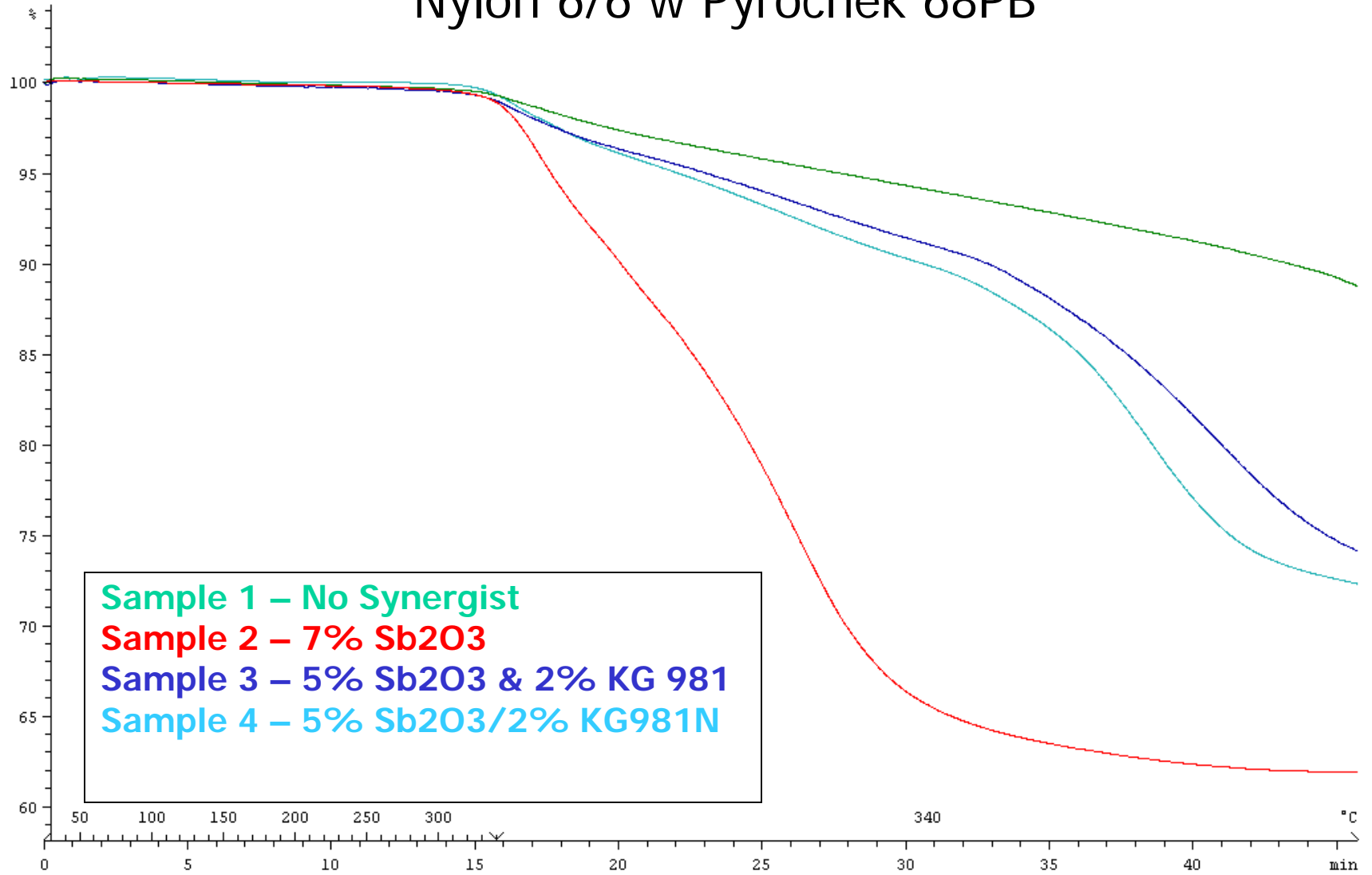
# DMA Comparison

## Glass filled Nylon 6/6

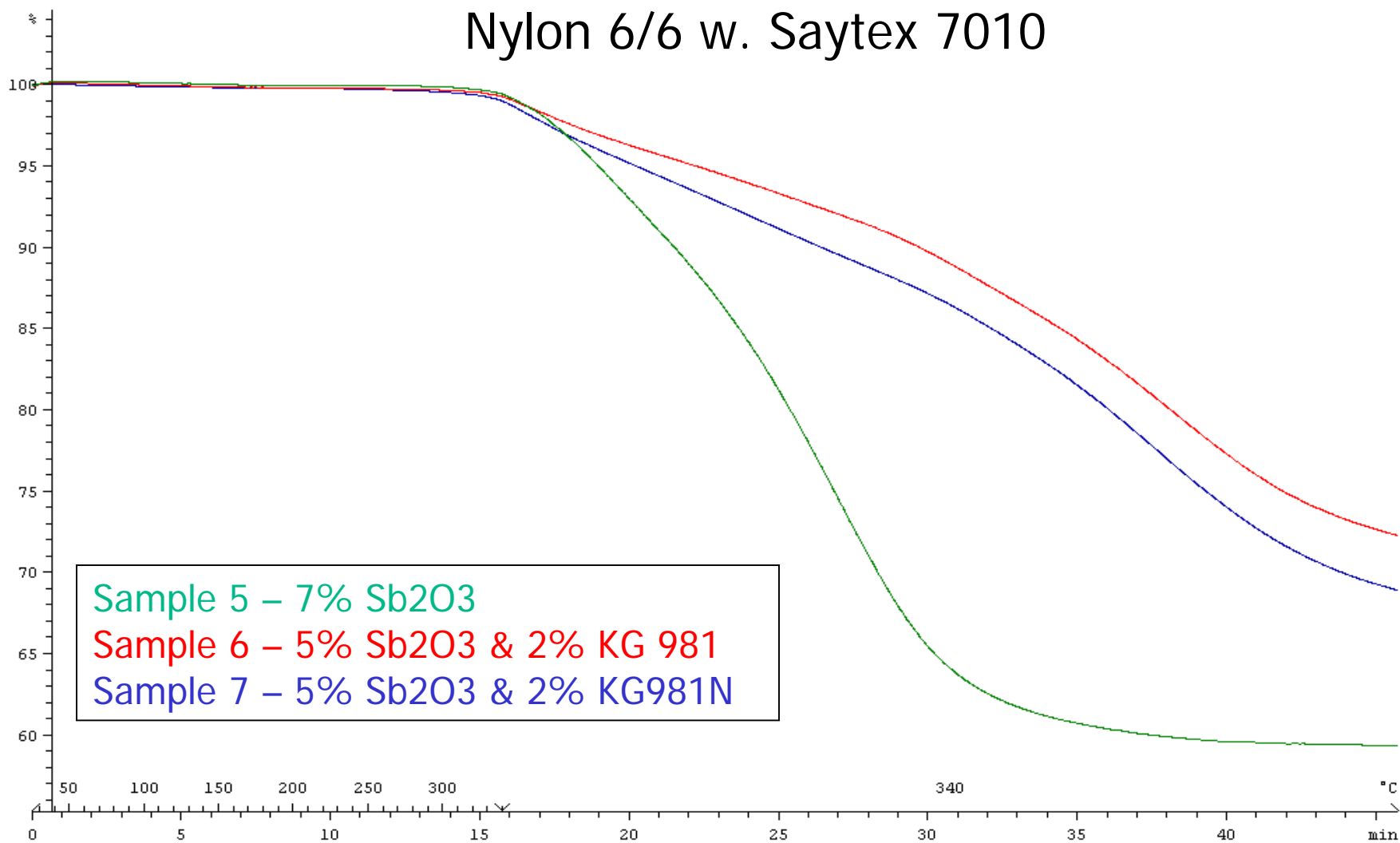
### Effect of Kemgard 981N

<u>SAMPLE</u>	<u>E'(40°C)</u> <u>MegaPascals</u>	<u>E'(125°C)</u>	<u>E'(225°C)</u>	<u>Thermal Transitions (°C)</u>
2	13185+-31	6949+-230	2576+-13	55 +-2 /Tg; 180/Melt 1, 239/Melt 2
4	14621 +-384	7468+-163	2767+-139	53 +-2/Tg; 179/Melt 1, 234/Melt 2

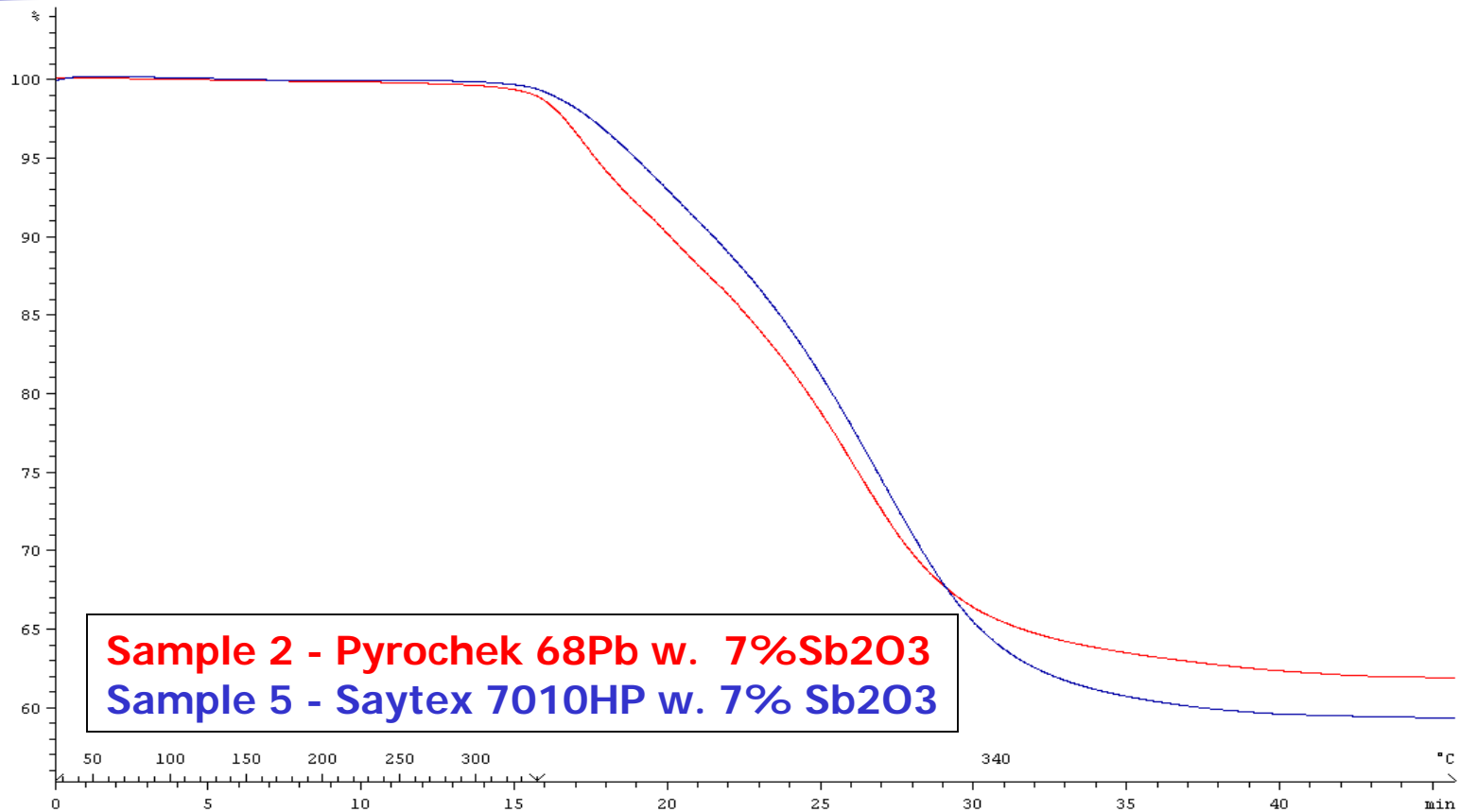
# Isothermal TGA 340 C Nylon 6/6 w Pyrochek 68PB



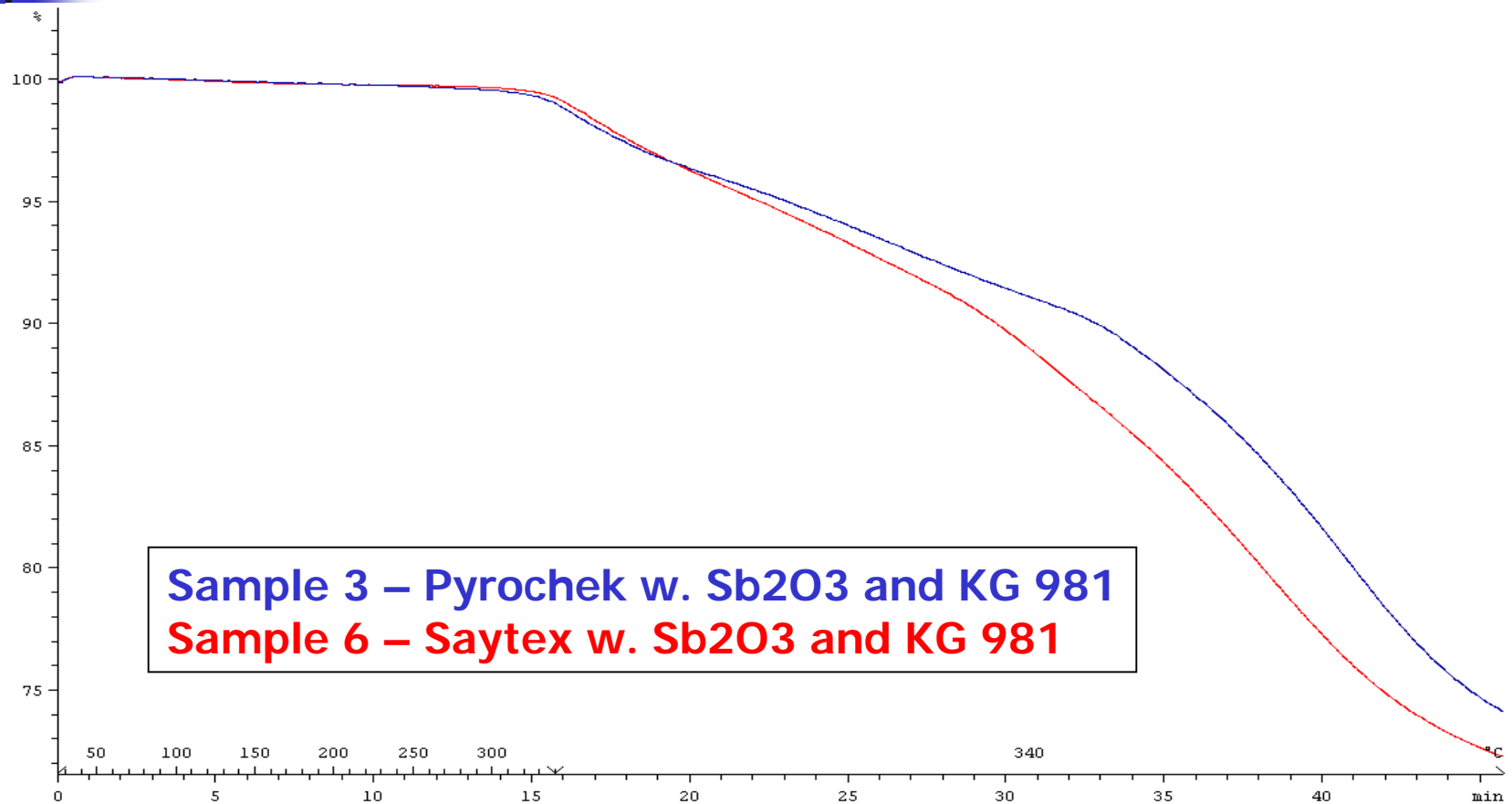
# Isothermal TGA 340 C Nylon 6/6 w. Saytex 7010



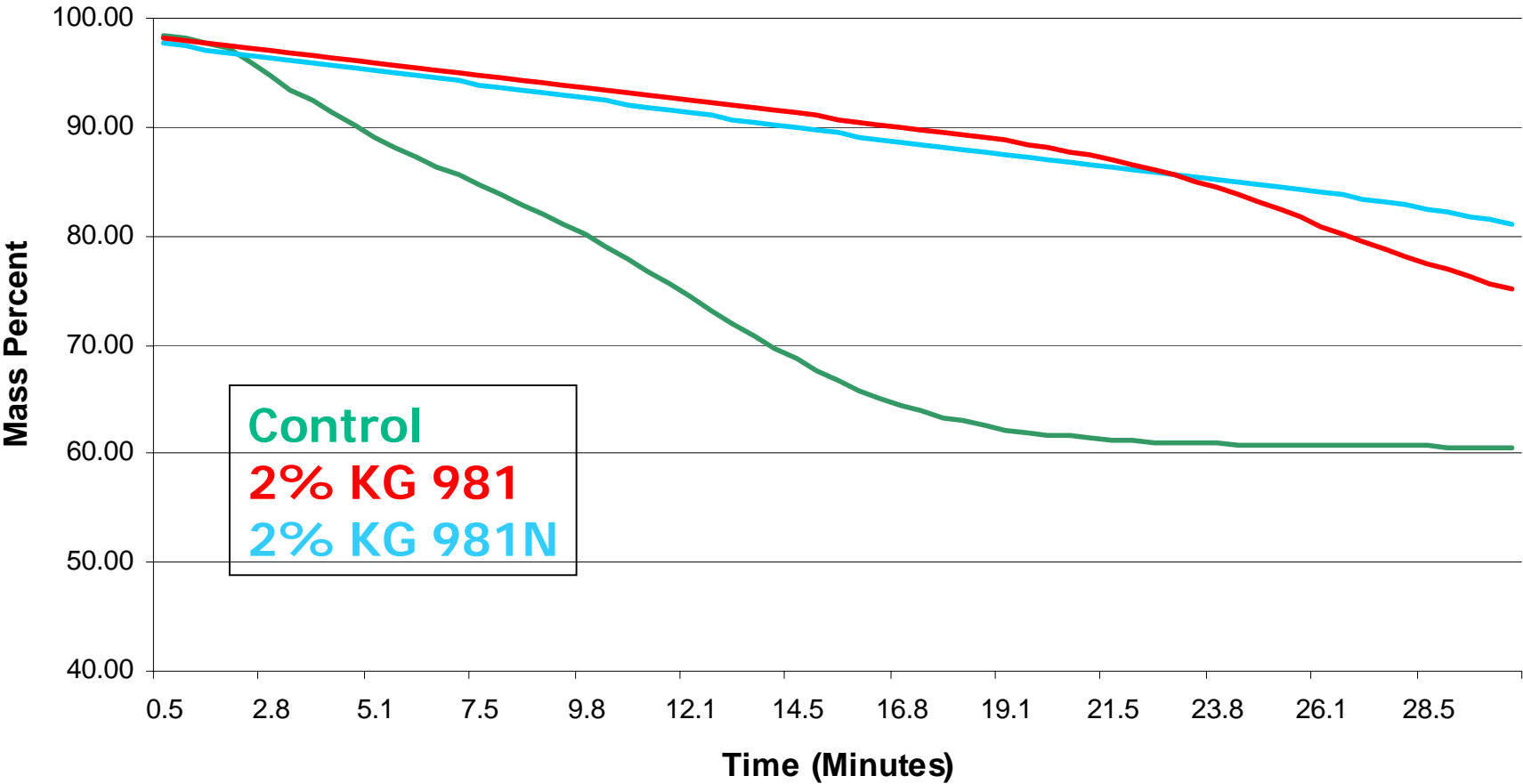
# Isothermal TGA 340 C Brominated FR Comparison



# Isothermal TGA 340 C. FR Comparison w. Kemgard



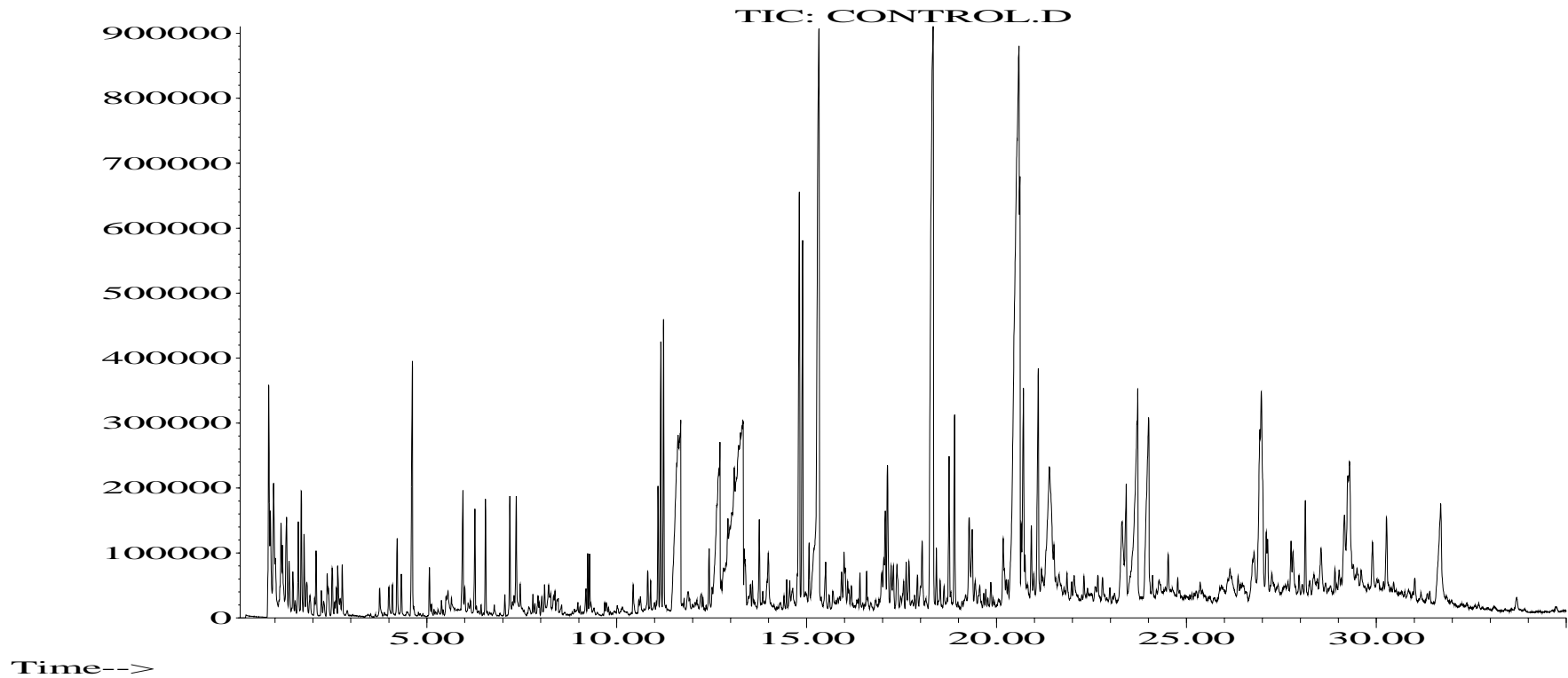
# Isothermal TGA 340 C Commercial Nylon 6/6 Compound



# Pyrolysis GC/MS

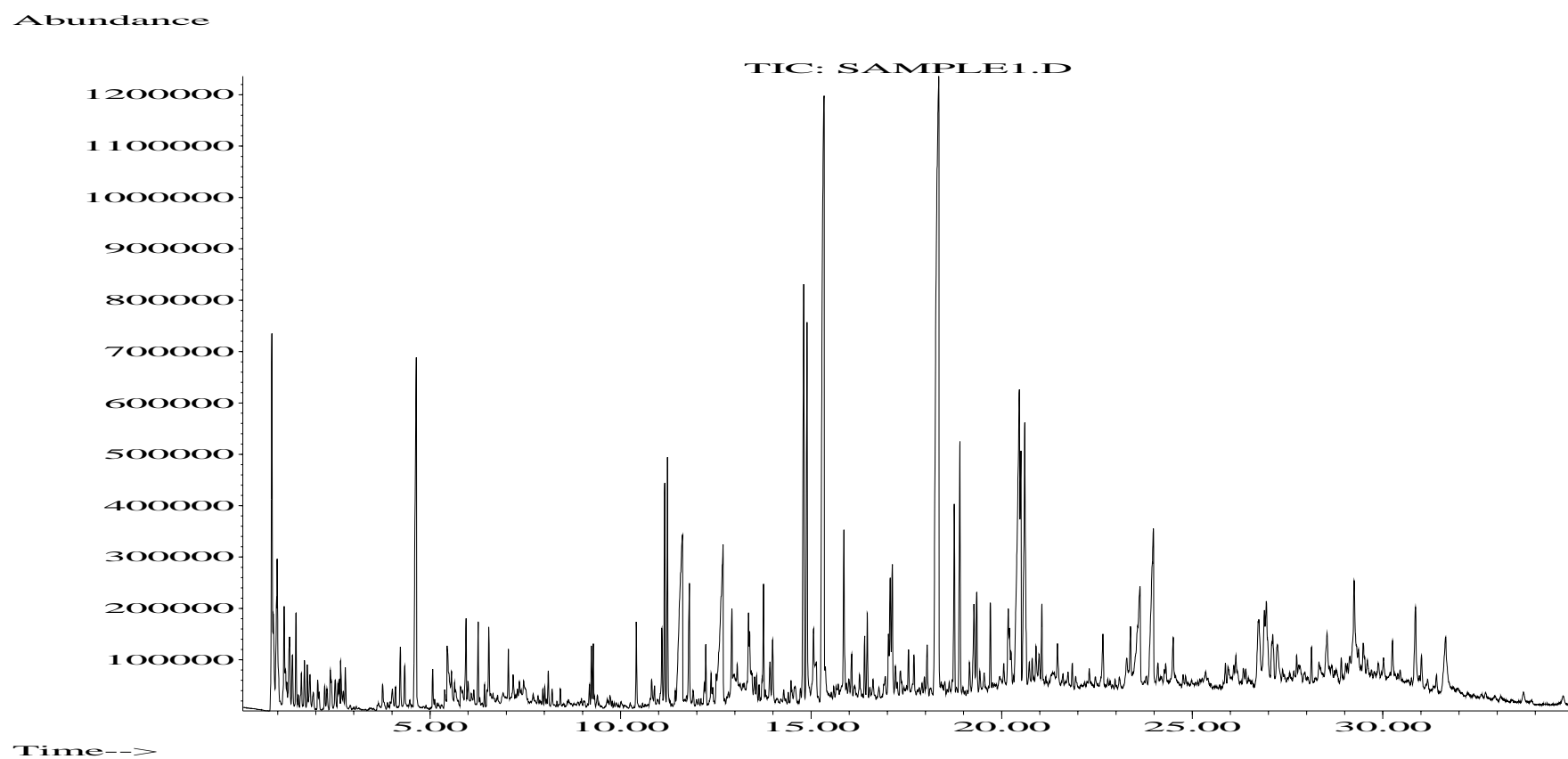
## FR Nylon 6/6 w. 7% Sb2O3

Abundance



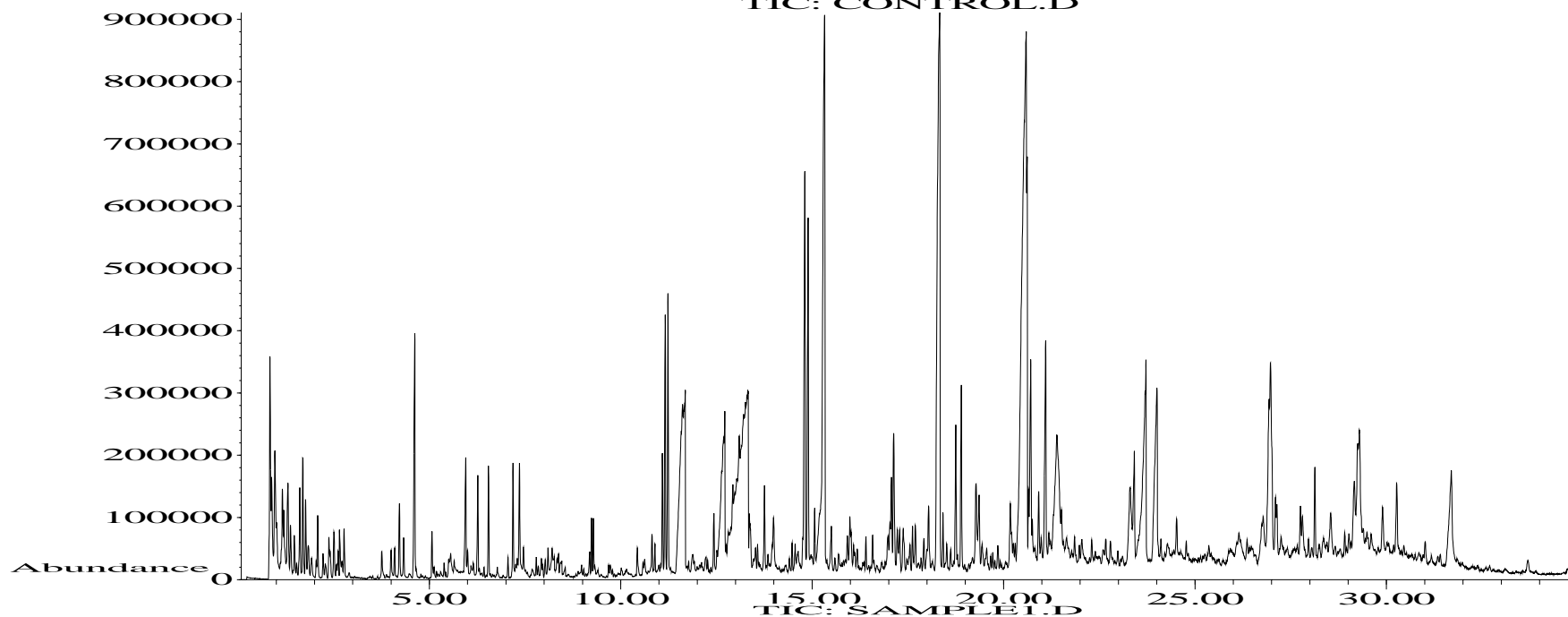
# Pyrolysis GC/MS

## FR Nylon 6/6 w. 5% Sb2O3 & KG 981



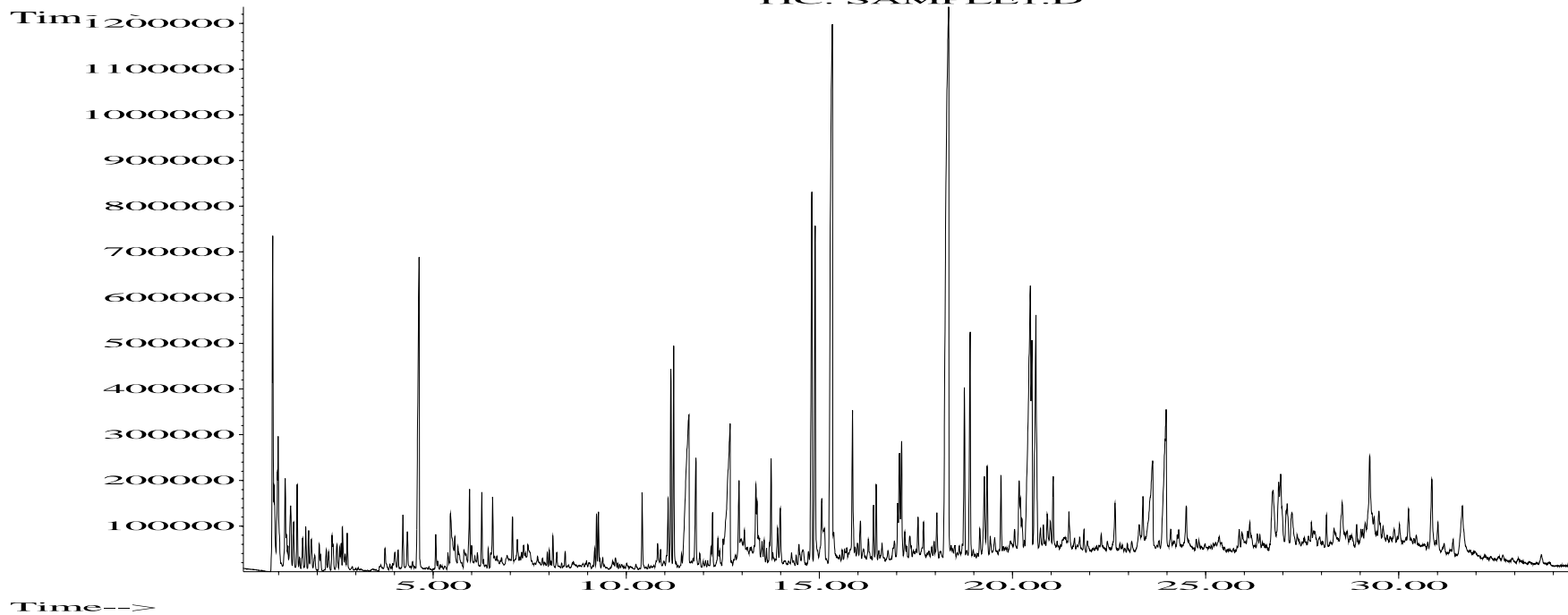
Abundance

TIC: CONTROL.D



Abundance

TIC: SAMPLE1.D



Time-->



# Kemgard 981 & 981N

## Char Formation in Nylon 6/6

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- TGA
  - Kemgard chemistry can influence the thermal stability of char layer
  - Optimum chemistry may be system dependent
- Pyrolysis GC/MS
  - Influence on polymer degradation products

Differences in char formation can influence FR performance



# KG 981 and KG 981N

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- Effective co-synergists in FR Nylon 6/6.
- Promote char formation in condensed phase.
- Improves thermal stability in FR Nylon 6/6
  - Higher Molding temperatures
  - Greater throughput
  - Lower mold corrosion
  - Improved electrical properties
  - Improved mechanical properties
  - Improved color

