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The Performance of Superslim Carbon Filters at Different Smoking Regimes

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Introduction

- Work presented at 62nd TSRC compared the adsorption characteristics of cigarette filters containing coconut and coal-based activated carbons at different activity levels under ISO, Massachusetts and Canadian Intense smoking regimes.
- As expected, the retention of vapour phase compounds by a carbon filter was found to decrease with increasing intensity of the smoking regime.
- One of the main factors affecting retention at more intense regimes is the greater smoke velocity (and shorter contact times) within the filter.
- Smoke velocities will also be higher for slimline cigarettes.
- This leads to the question of how the vapour phase retention of superslim carbon filters compares to that previously reported for standard circumference cigarettes.

Smoke Velocities

- Smoke velocities through the filter depend on the physical dimensions of the filter and the puff volume / duration.
- The cross-sectional area of a superslim (16.5 – 17.0 mm circumference) filter is around half that of a standard (c.24.5 mm circumference) filter. This leads to an approximate doubling of smoke velocity through a superslim filter under the same smoking conditions.
- However, for the same weight of carbon, the length of the adsorbent bed in a superslim carbon granular filter will be greater than a standard circumference filter and the overall smoke residence times in the carbon beds will be comparable.

Experimental Plan

- This study explores the vapour phase retention of superslim filters containing coconut-based carbon of two different activities under ISO and Canadian Intense regimes.
- The work was limited to non-ventilated cigarettes so vent-blocking effects would not be a factor
- In addition to smoking regime, this work explores the effects of:
  - Carbon activity level – 'medium' and 'high'
  - Carbon weight – 15, 30, 45 and 90mg per tip
- Comparisons are drawn with standard circumference cigarettes

Materials Tested

- Two commercially available coconut-based carbons of 60 CTC and 100 CTC activity
- Referred to in this paper as ‘M’ and ‘H’
- All materials were selected to the same particle size range (30/70 US mesh)

Raw Material	Sample Ref	Moisture Content (%)	Wet Density (g/ml)	Cyclohexane Activity (%)	BET Surface Area (m^2/g)
Coconut	M	14.7	0.57	30	1100
	H	7.7	0.42	49	1600

Test Filter

Dried Carbon Granules

1

Empty Tube

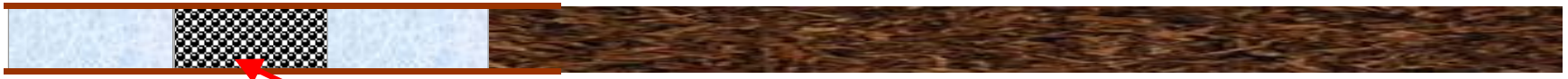
Tobacco End Acetate Plug

2

Mouth End Acetate Plug

Test Cigarette Construction

Test Cigarette



Carbon – Different weights and activities

Control Cigarette

Analytical Procedures

Methodology

- Cigarettes tested around three weeks after assembly
- Vapour phase collected in gas sampling bag for analysis by GC-MS
- Tar, nicotine and CO Yields also measured for both smoking regimes

Vapour Phase Compounds Measured

- Aldehydes – Acetaldehyde, Acrolein, Propionaldehyde, Butyraldehyde and Crotonaldehyde
- Ketones - Acetone and Methyl Ethyl Ketone
- Hydrocarbons – 1,3 Butadiene, Isoprene, Benzene and Toluene
- Cyanides – Acrylonitrile

Calculation of Vapour Phase Compound Retention

$$\% \text{ Retention} = \frac{(\text{Control Cigarette GC Peak Area} - \text{Test Cigarette GC Peak Area})}{\text{Control Cigarette GC Peak Area}} \times 100$$

Mean Aldehyde Retention = Arithmetic Mean of the Retention of the Five Measured Aldehydes

Mean Hydrocarbon Retention = Arithmetic Mean of the Retention of the Four Measured Hydrocarbons

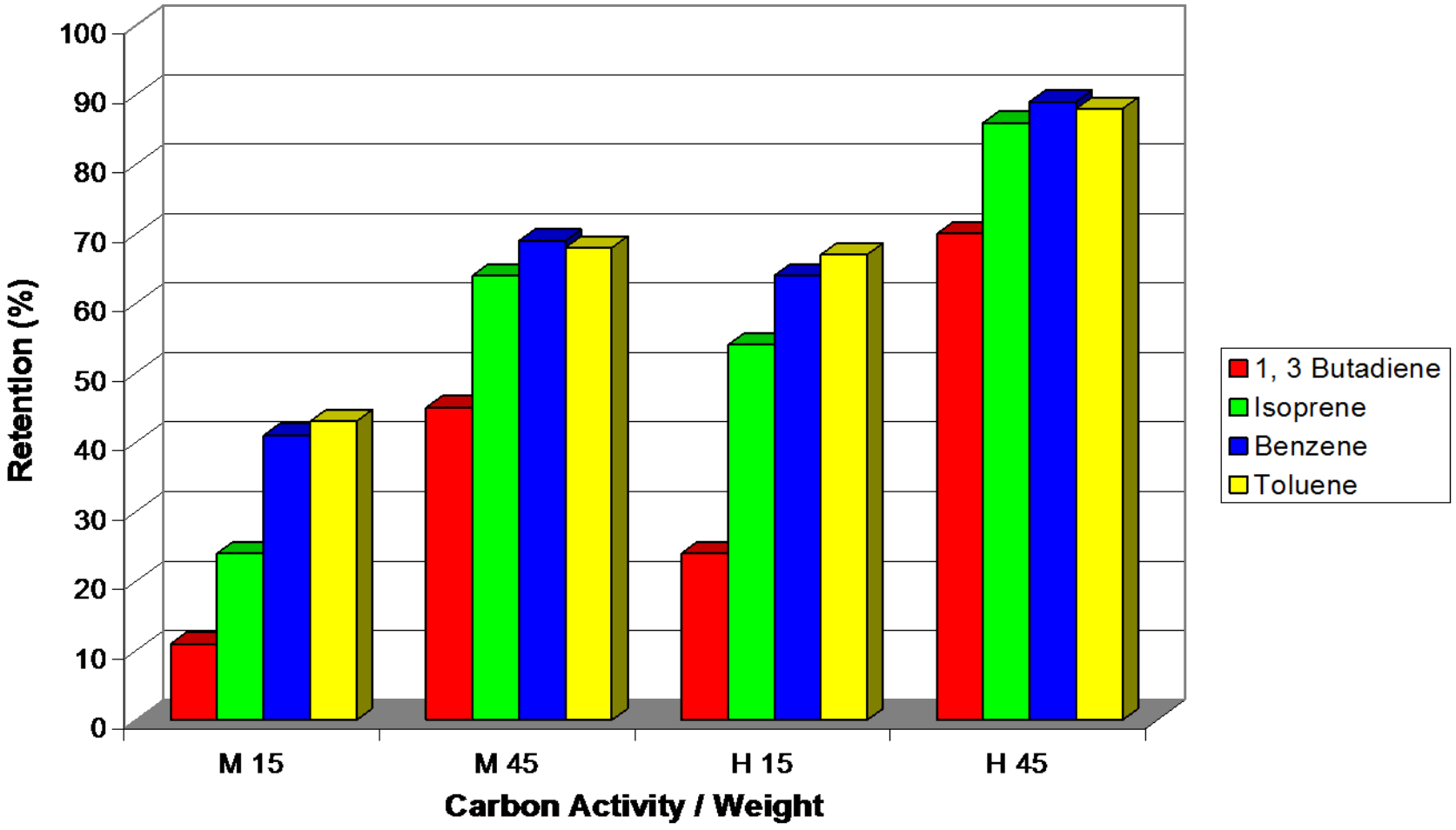
Smoke Testing – Control Cigarettes

Smoking Regime	Puff Regime	Puff Number	Tar Delivery (mg/cig)	Nicotine Delivery (mg/cig)	CO Delivery (mg/cig)
ISO	35/2/60	6.6	13.0	0.55	9.3
Intense	55/2/30	9.2	25.6	1.24	16.8

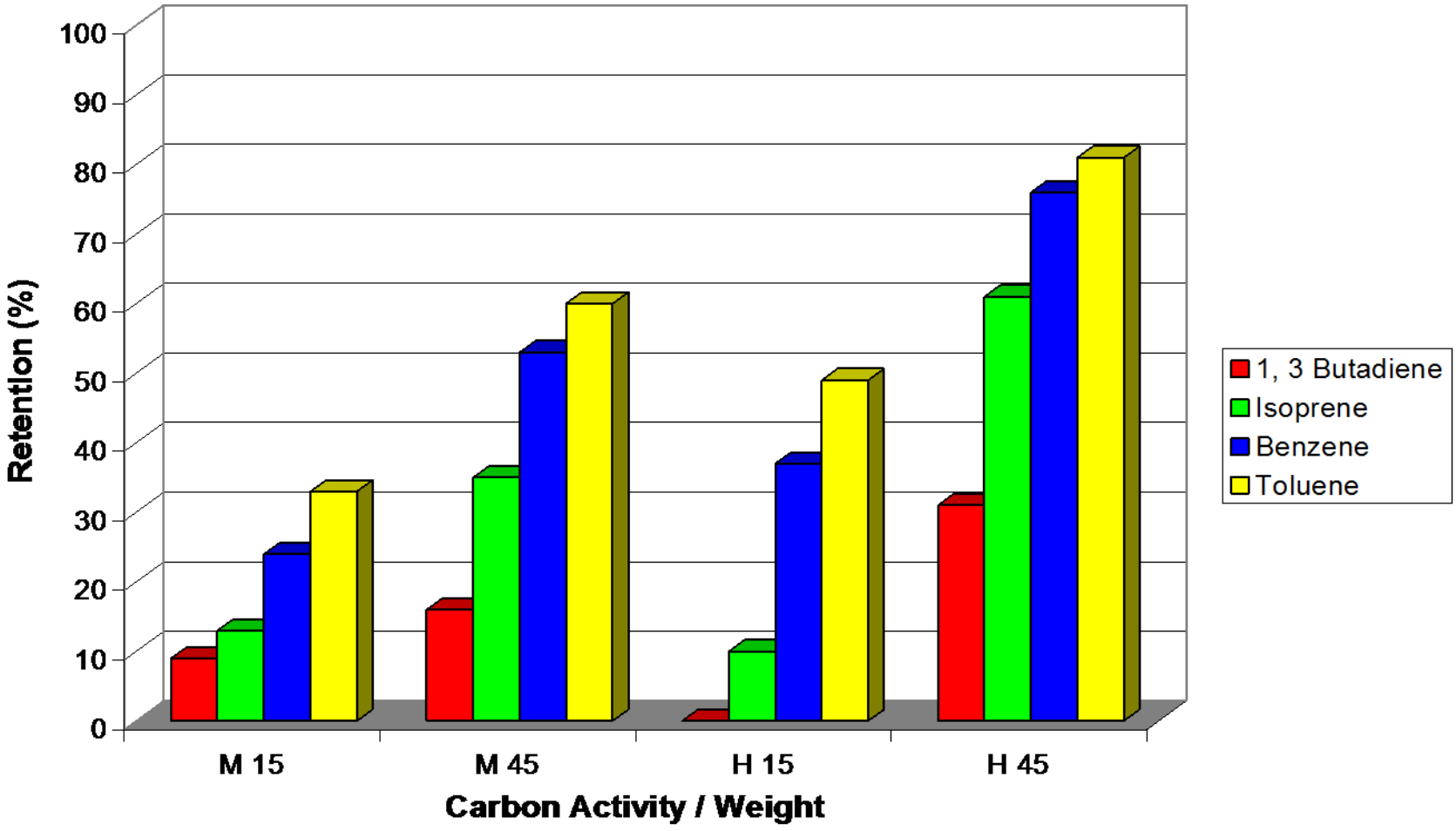
Filter Particulate Retention

	Superslim (Circumference 16.7 mm)		Standard (Circumference 24.5 mm)	
	ISO	Intense	ISO	Intense
Filter Tar Retention (%)	26.7	25.5	42.8	41.0
Filter Nicotine Retention (%)	20.1	19.7	36.4	34.0

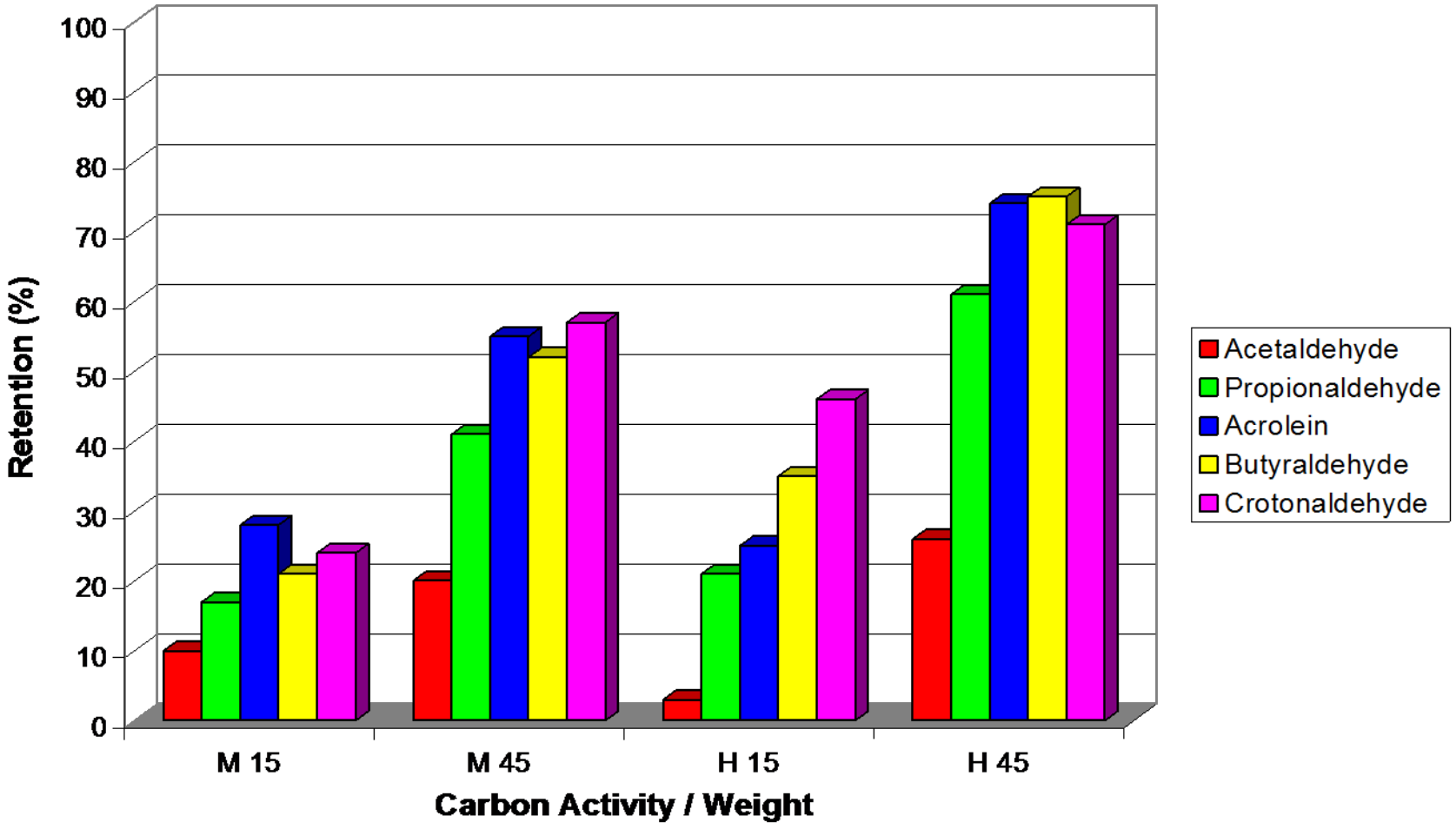
Retention of Hydrocarbons by Superslim Filters – ISO Smoking



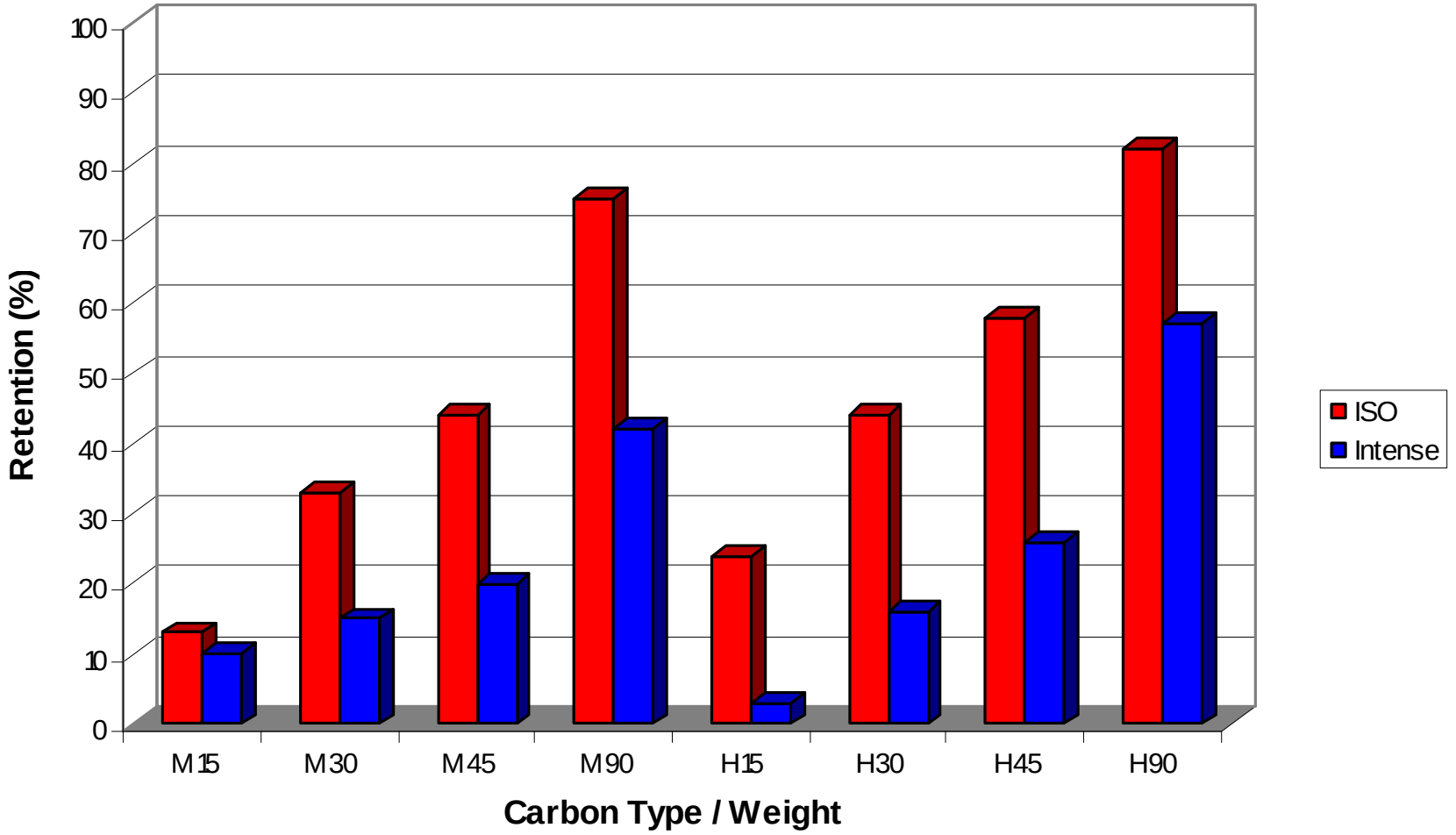
Retention of Hydrocarbons by Superslim Filters - Intense Smoking



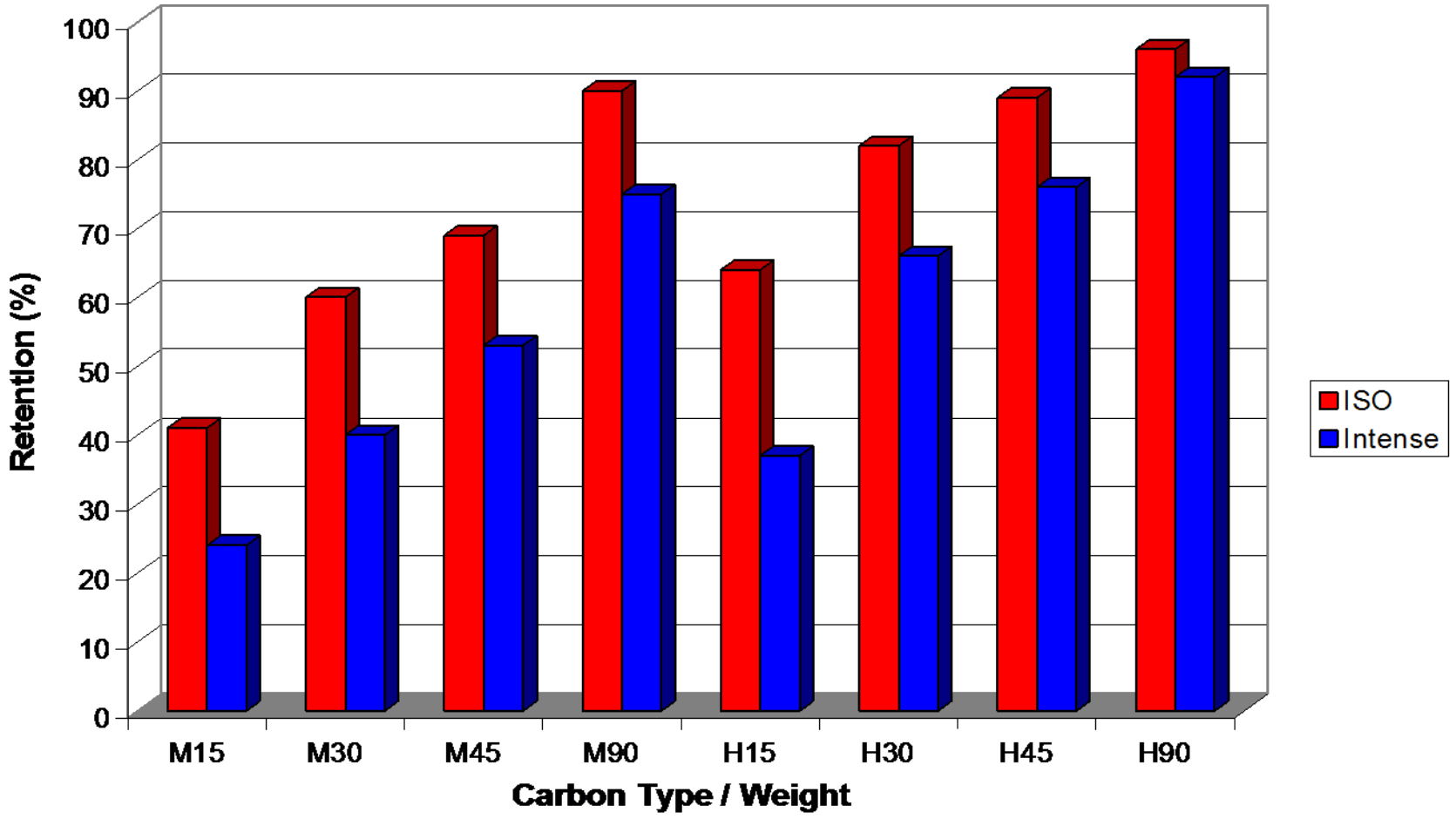
Retention of Aldehydes by Superslim Filters - Intense Smoking



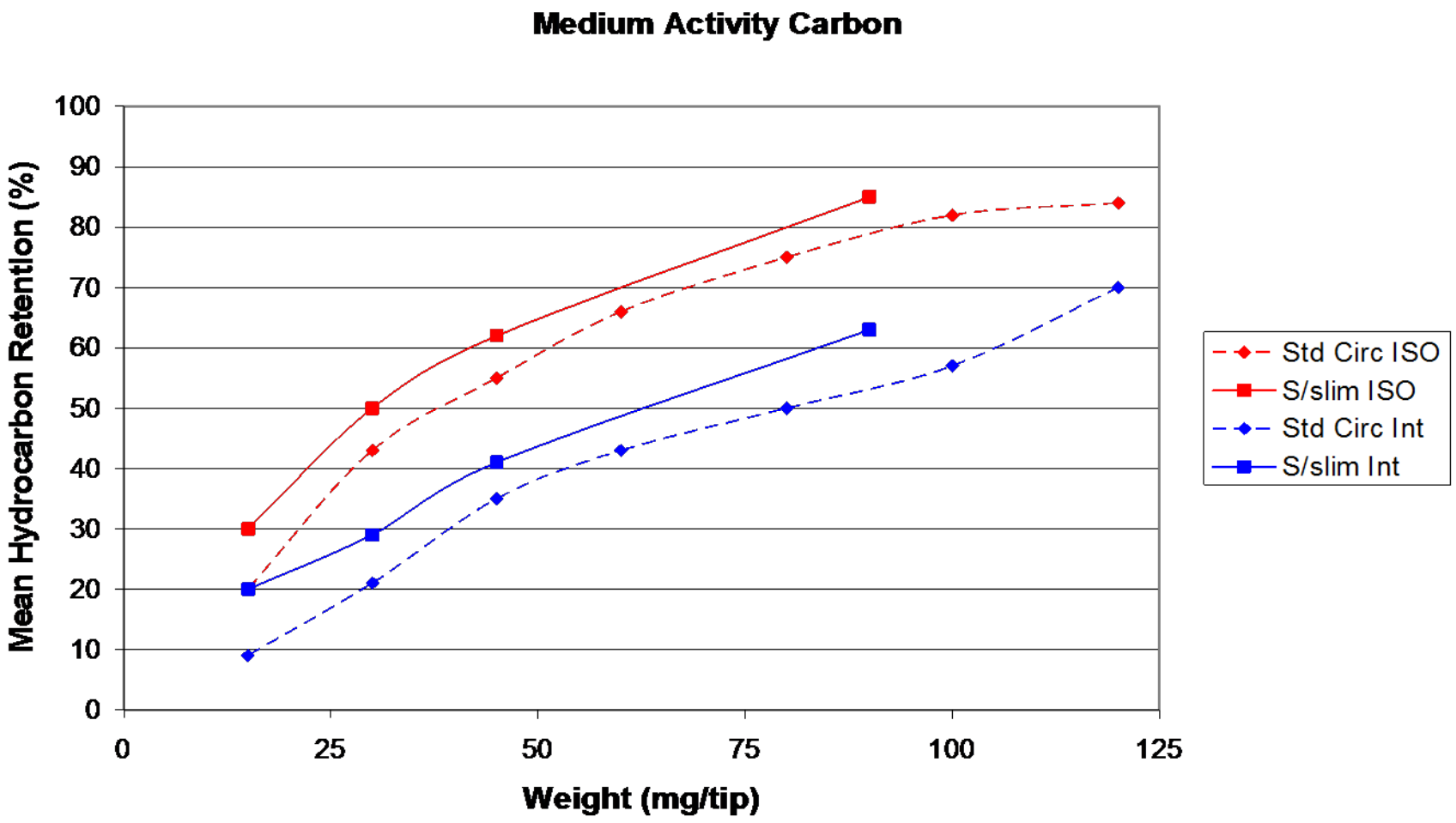
Retention of Acetaldehyde by Superslim Filters



Retention of Benzene by Superslim Filters



Retention of Hydrocarbons by Superslim and Standard Circumference Filters



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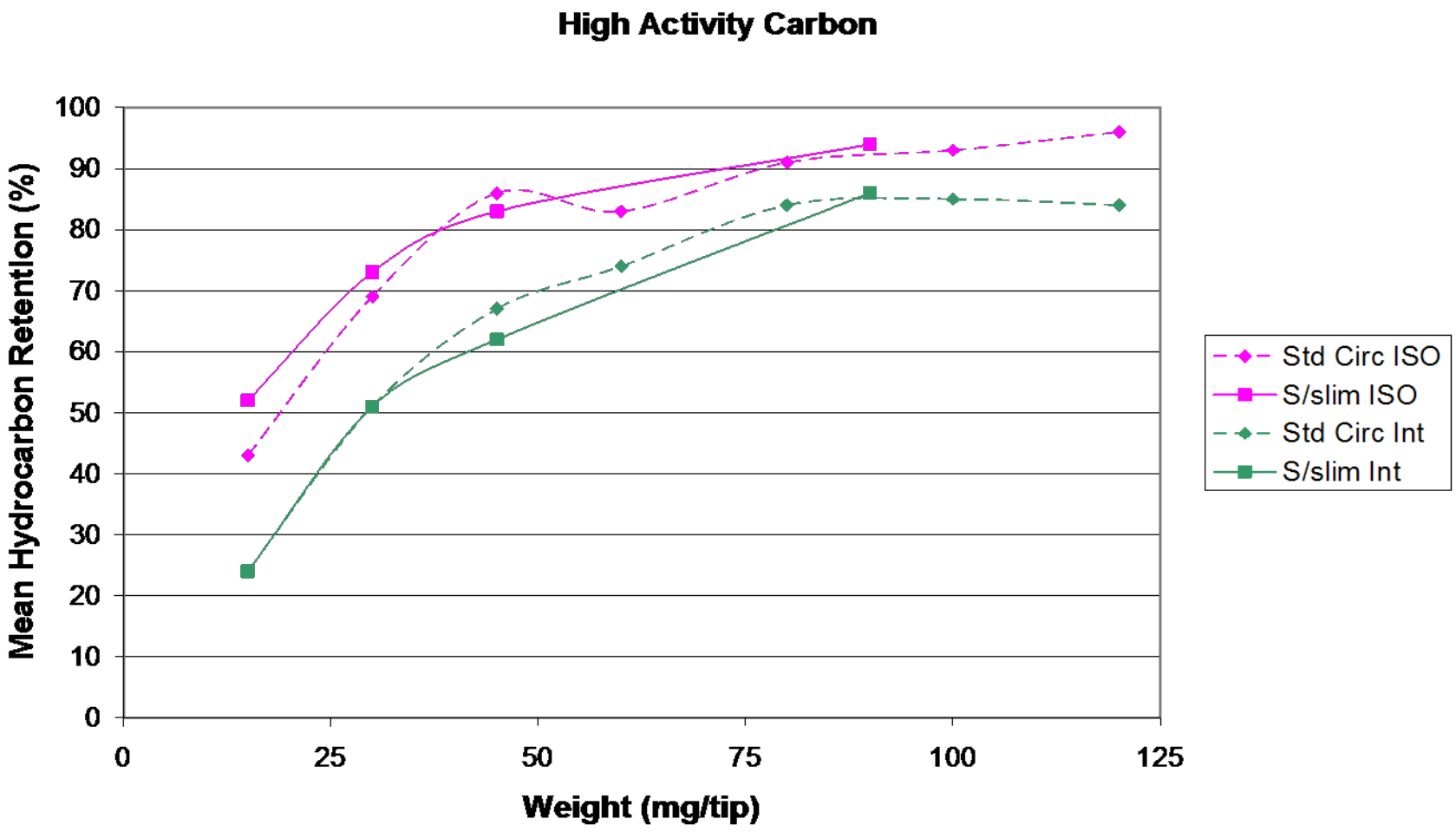
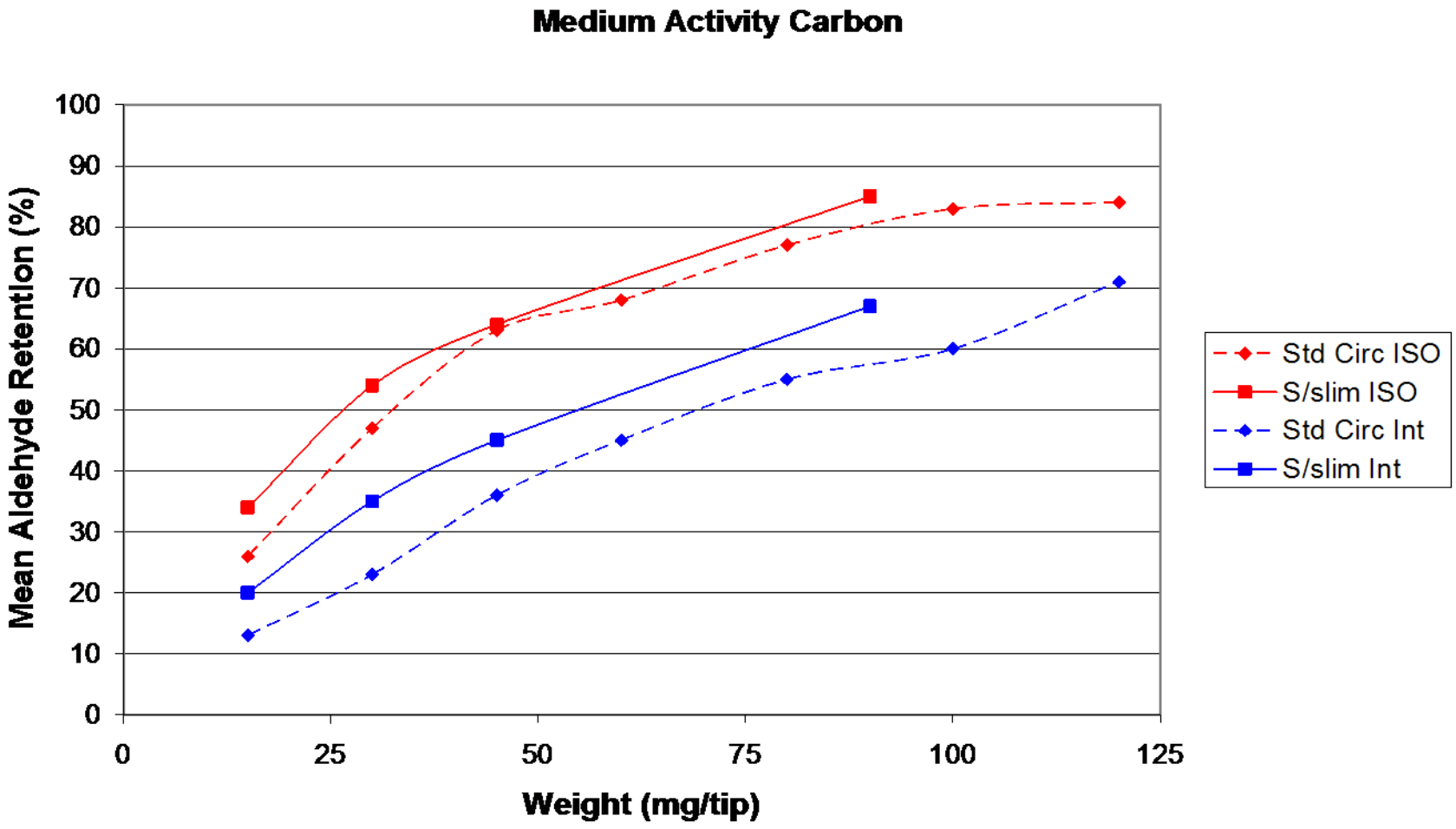
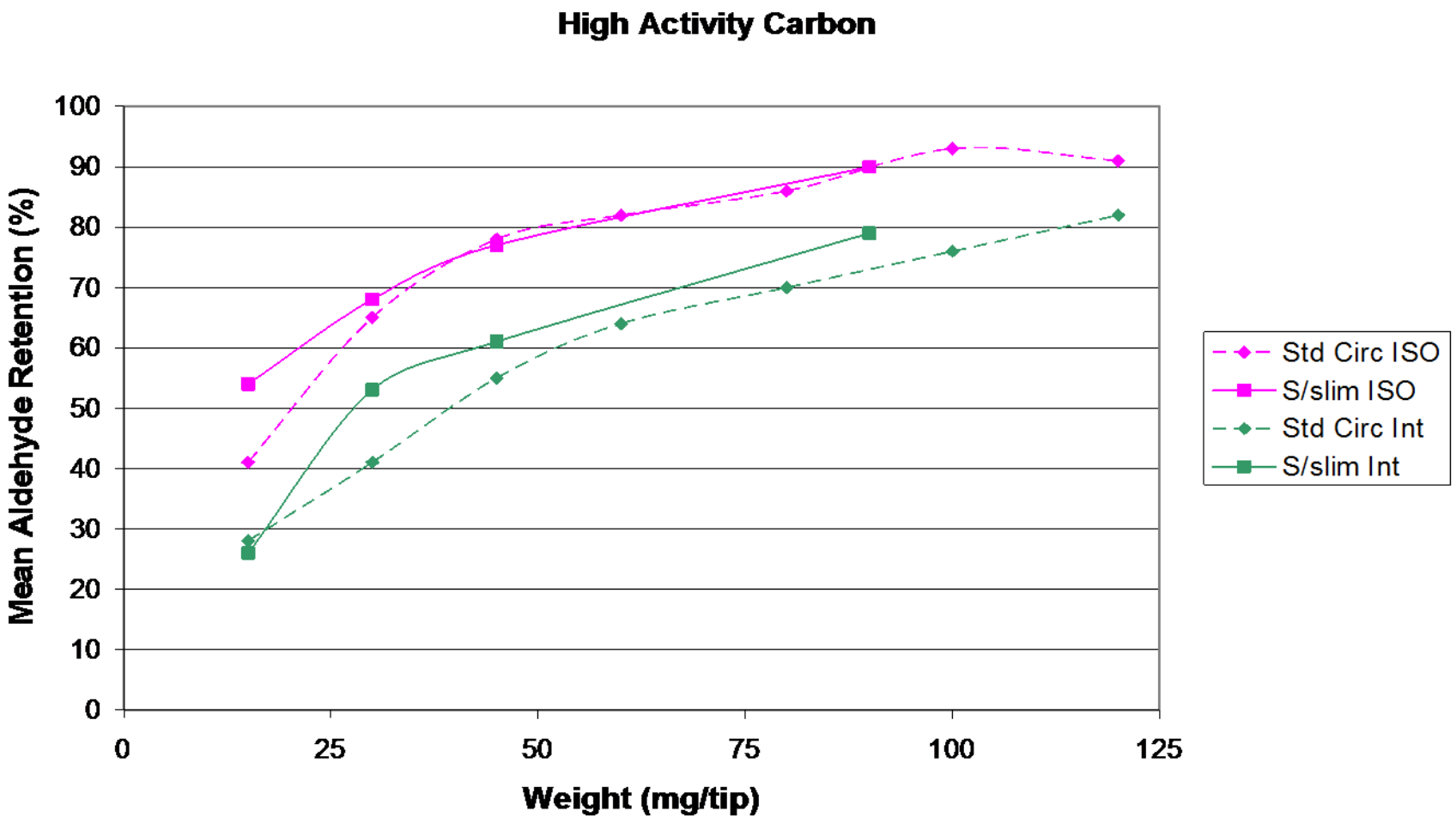


Retention of Aldehydes by Superslim and Standard Circumference Filters



Retention of Aldehydes by Superslim and Standard Circumference Filters



Conclusions

- Carbon remains an effective material for the removal of vapour phase compounds in slimline filters
- The trends of vapour phase retention previously observed for standard circumference filters are also apparent in slimmer products, for example:
  - Retention increases with increasing carbon weight and carbon activity
  - Higher boiling point vapour phase compounds are retained more efficiently than comparable lower boiling point compounds
  - Retention decreases with increasing intensity of the smoking regime
- On a constant carbon weight basis, the percentage retention of vapour phase compounds is slightly higher for superslim than standard circumference filters.
- The enhanced retention by superslim carbon filters can be observed at different smoking regimes, different carbon activities and across all chemical species.
- In reality, the weight of carbon used in a superslim filter is likely to be less than a standard circumference product and care needs to be taken when comparing similar adsorbent weights across such products.

Further Studies

- This study has only considered retention rather than yield data.
- In superslim cigarettes, vapour phase yields will be lower than for standard circumference cigarettes and hence the actual amount of material adsorbed by the carbon is less.
- A further paper will be presented at CORESTA 2009 examining the vapour phase yield from superslim cigarettes at different smoking regimes.

Thank you for your attention