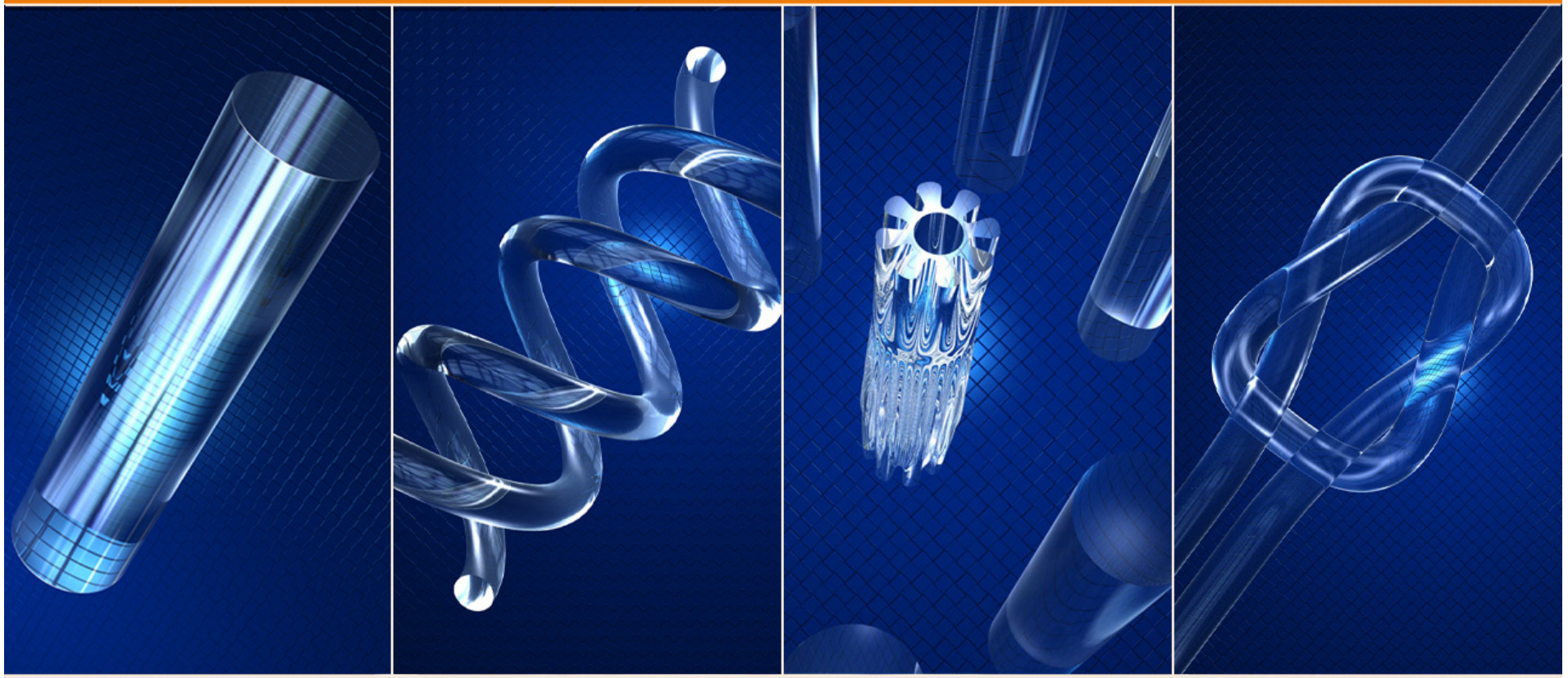
{ quality } { partnership } { innovation } { knowledge }



Filter Additives for the Selective Filtration of Phenols from Cigarette Smoke

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FILTRONA

the difference is { everything }

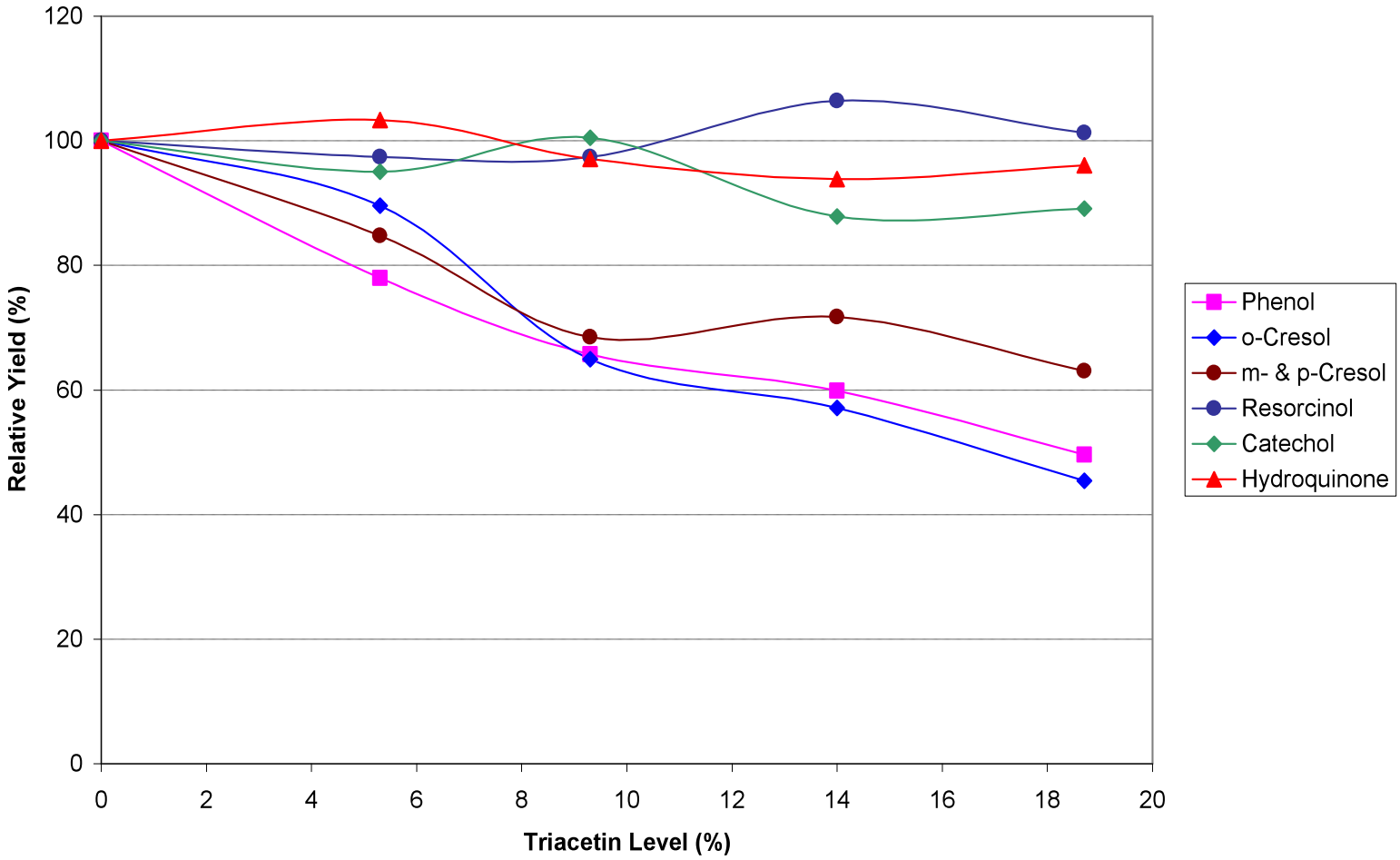
Introduction

- Phenols are known toxic substances in cigarette smoke that have previously been identified as target compounds for selective filtration
- It is well-known that cellulose acetate filters plasticized with triacetin exhibit enhanced filtration of phenols
- There is a need to enhance the removal of phenolic compounds from smoke for:
  - Cellulose acetate filters where still further reduction in phenols is required
  - Filter products using less cellulose acetate material (e.g. highly ventilated low retention filters) where otherwise the yield of phenols could increase relative to other smoke constituents
  - Filters containing paper
- This paper describes the results from experimental trials to identify filter additives that can increase the selective filtration of phenols, in particular by cellulose acetate filters

Important Phenols in Cigarette Smoke

Compound	Boiling Point (°C)	Typical Yields (µg/cig)	Availability for Selective Filtration
Phenol	182	< 50	Moderate
o-Cresol	191	< 10	
m- and p-Cresol	202/3	< 25	
Resorcinol	d 178	< 20	Low to Moderate
Catechol	245	< 120	
Hydroquinone	285	< 125	Negligible

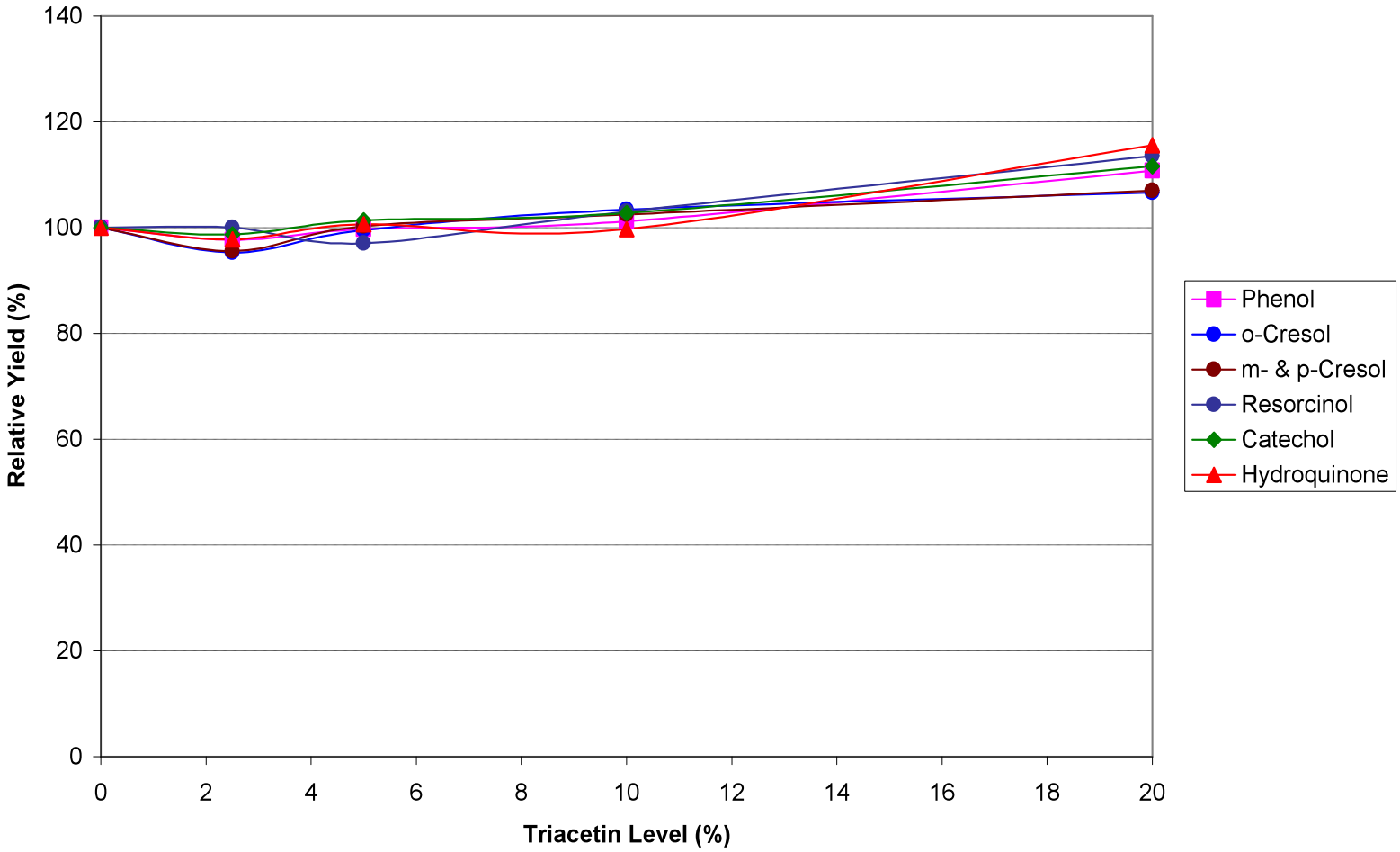
Effect of Triacetin Level on Phenol Reduction (Machine CA Filters)



Experimental Methodology

- Initial attempts were made to develop a method for applying additives to paper filters so that selective effects due to cellulose acetate could be eliminated
- As an initial screen to verify the methodology, the effects of adding triacetin to paper were measured
- These tests involved dissolving triacetin in propanol, adding the mixture to paper filters such that it wicked evenly across the filter and then allowing the solvent to evaporate
- Various loadings of triacetin between 2.5 and 20% were applied in this fashion
- Filter cigarettes were assembled and smoked under ISO conditions and the yields of the seven phenolic compounds quantified

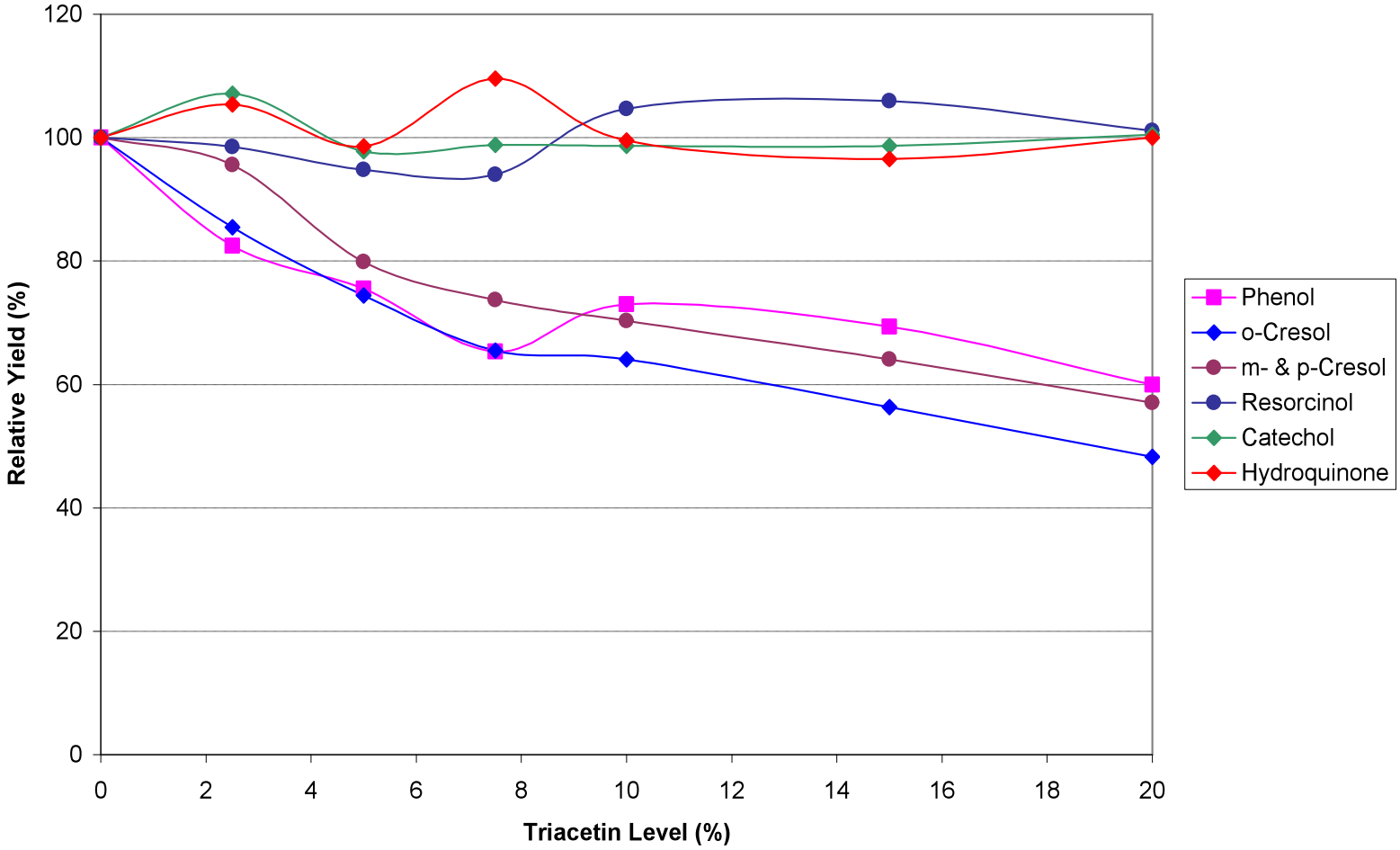
Effect of Triacetin Level on Phenol Reduction (Paper Filters)



Refined Experimental Methodology

- It was clear that applying liquid additives to paper filters does not necessarily reproduce the effects observed in cellulose acetate filters
- Tests were carried out to establish whether wicking controlled amounts of triacetin in propanol to unplasticized cellulose acetate filters in the laboratory gave similar results to machine-made filters

Effect of Triacetin Level on Phenol Reduction (Laboratory CA Filters)



Screening Experiments

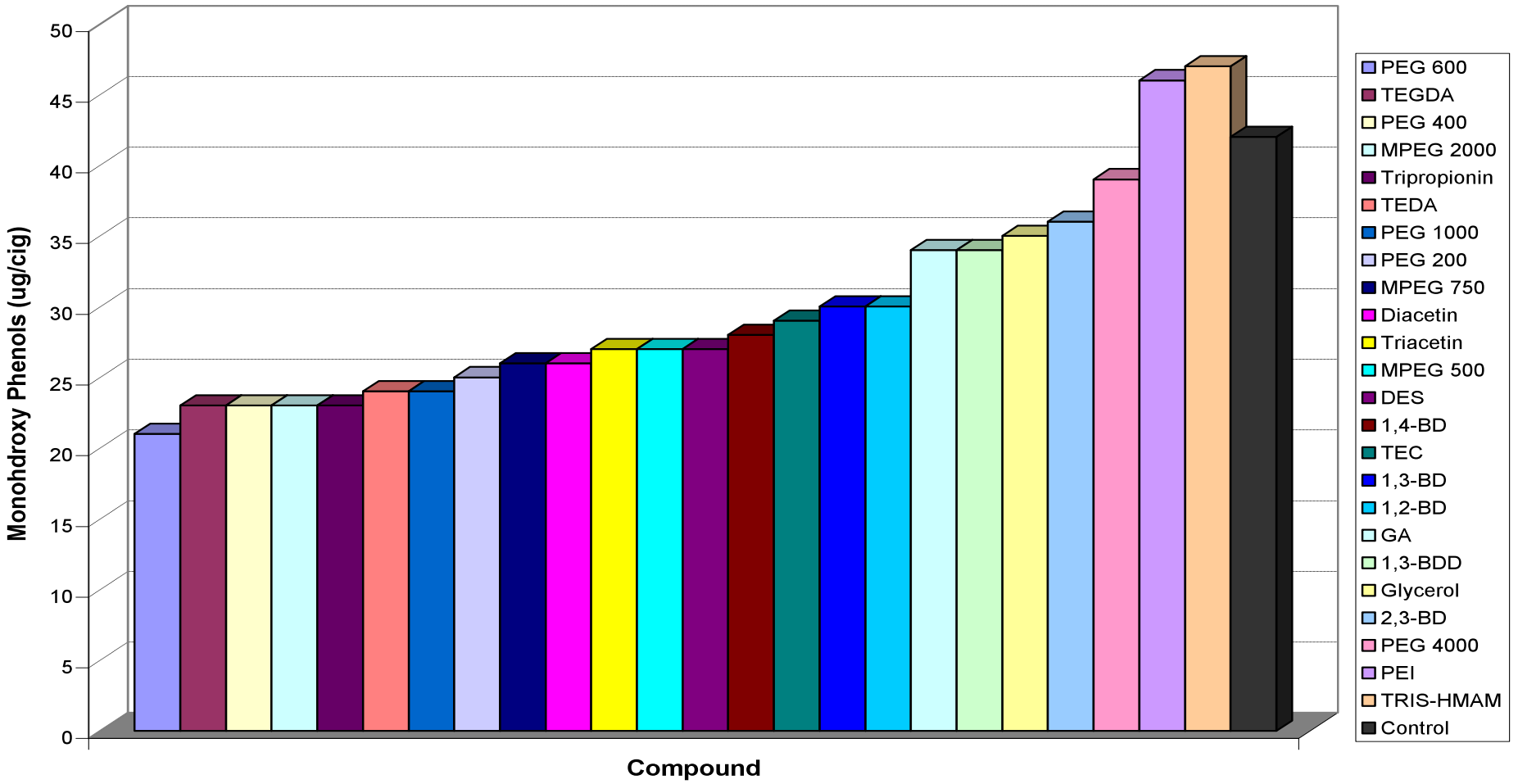
- The laboratory wicking procedure gave similar results to machine-made CA filters, so this method was used to screen the liquid additives studied during this work
- A number of chosen additives were each applied at a single (20% w/w) level to unplasticized CA filters

Liquid Additives Screened

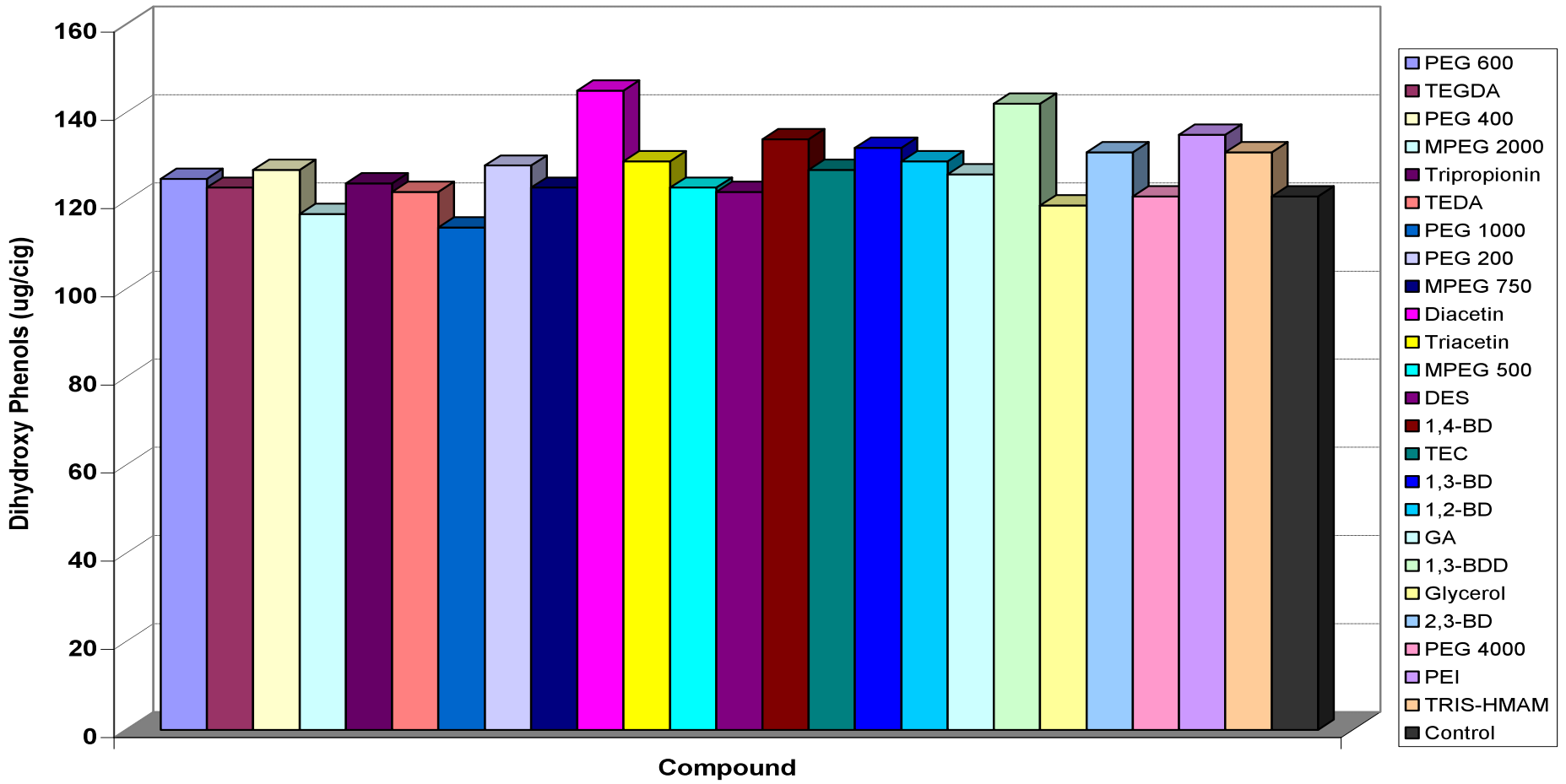
- The following 24 compounds were evaluated during the laboratory screening trials for their effect on phenols

Triacetin	1,2-Butanediol	Diethyl Succinate
Triethyl Citrate	1,3-Butanediol	Polyethyleneimine
TEGDA	1,3-Butanediol Diacetate	Polyethylene Glycol (200, 400, 600, 1000 & 4000)
Tripropionin	2,3-Butanediol	Methoxy Polyethylene Glycol (500, 750 & 2000)
Diacetin	1,4-Butanediol	TEDA
Glycerol	Glycerol Monoacetate	TRIS-HydroxyMethylAminoMethane

Screening of Additives – Effect on Mono-Hydroxy Phenols

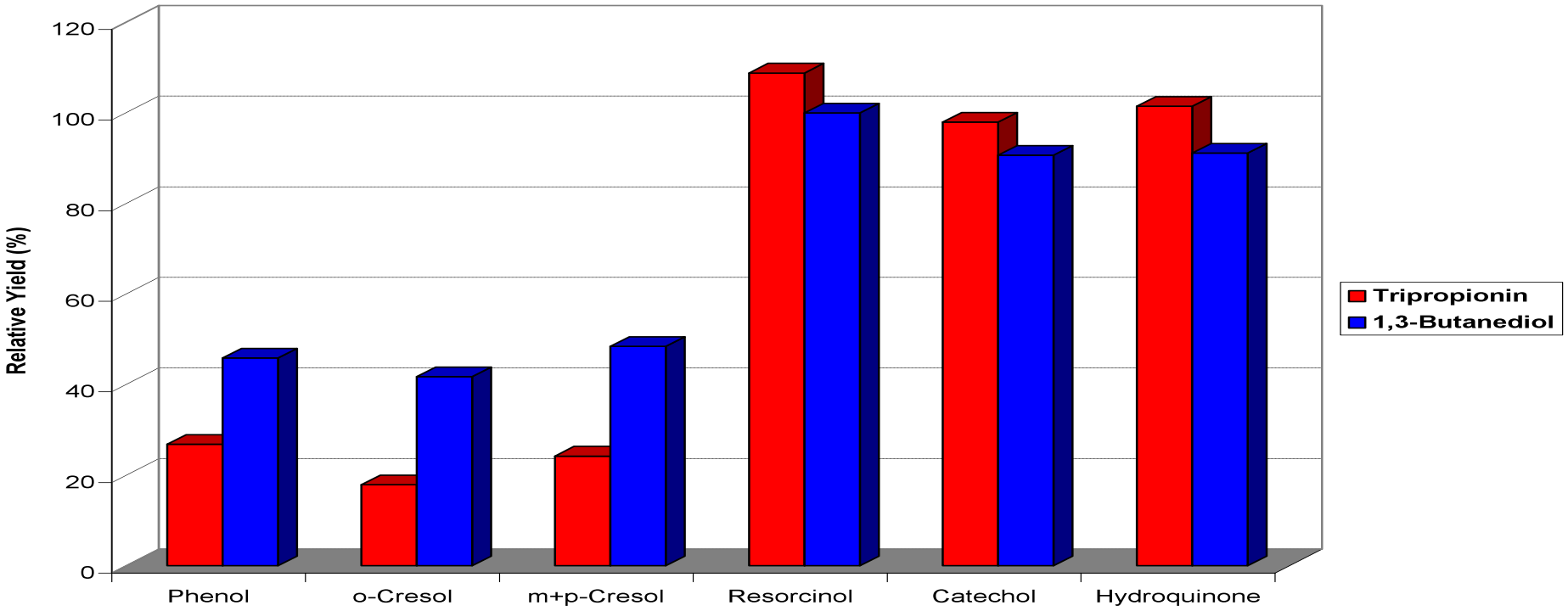


Screening of Additives – Effect on Di-Hydroxy Phenols



Further Trials

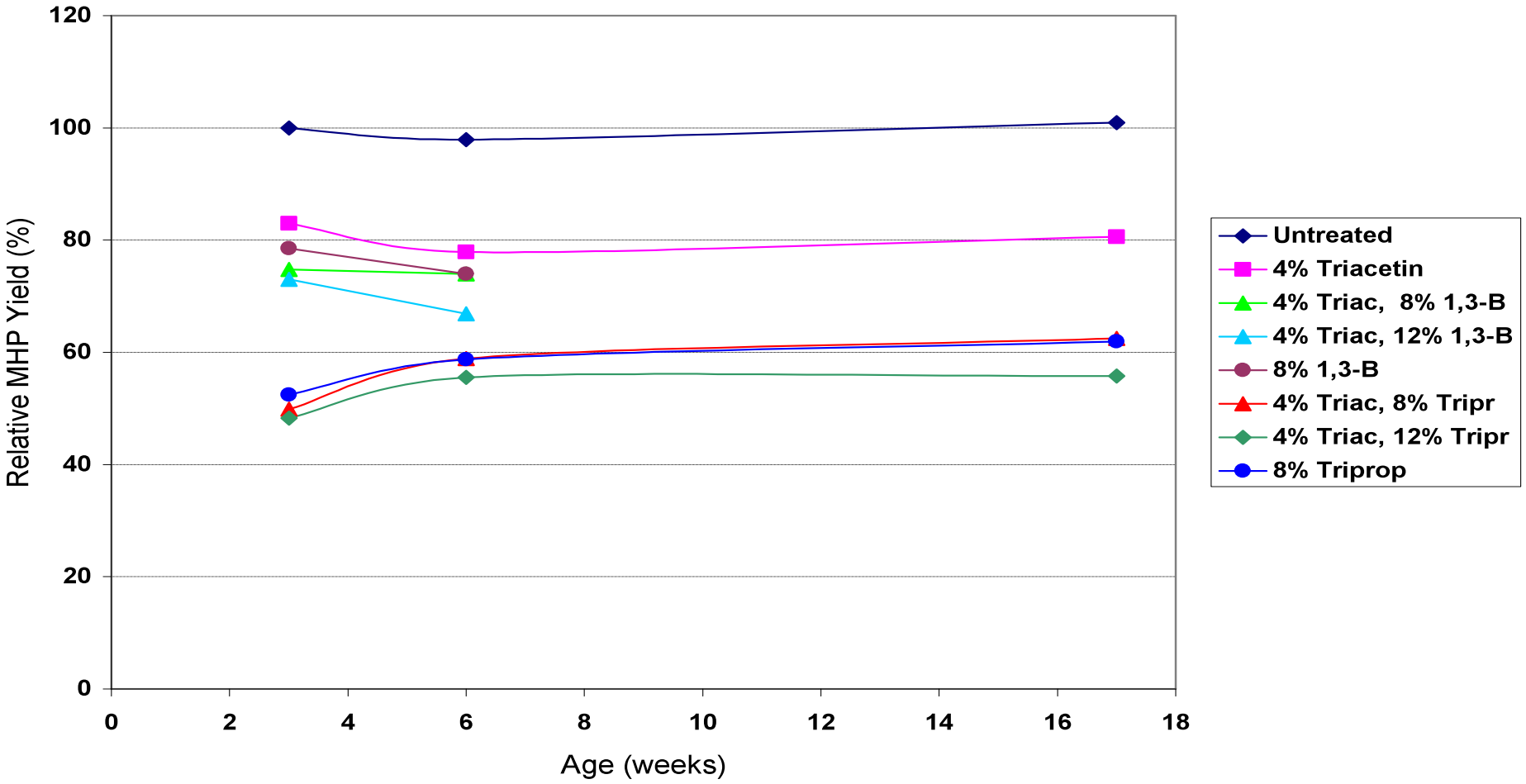
- On the basis of our studies, the two most promising additives for phenols reduction were identified as tripropionin and 1,3-butanediol.
- Filters were prepared by allowing each neat additive to saturate an unplasticized tip
- Both additives exhibited a mild plasticizing effect



Machine-made Filter Trials - 1

- Cellulose acetate filters were made by machine using varying amounts of triacetin, tripropionin and 1,3-butanediol:
  - Untreated
  - 4% triacetin
  - 4% triacetin AND 8% tripropionin or 8% 1,3-butandediol
  - 4% triacetin AND 12% tripropionin or 12% 1,3-butandediol
  - 8% tripropionin or 8% 1,3-butandediol
- Yields of phenols were tested after filter cigarettes had been aged for 3, 6 and 17 weeks
- Results for mono hydroxy phenols (i.e. phenol plus o-, m- & p- cresols) given in following slide

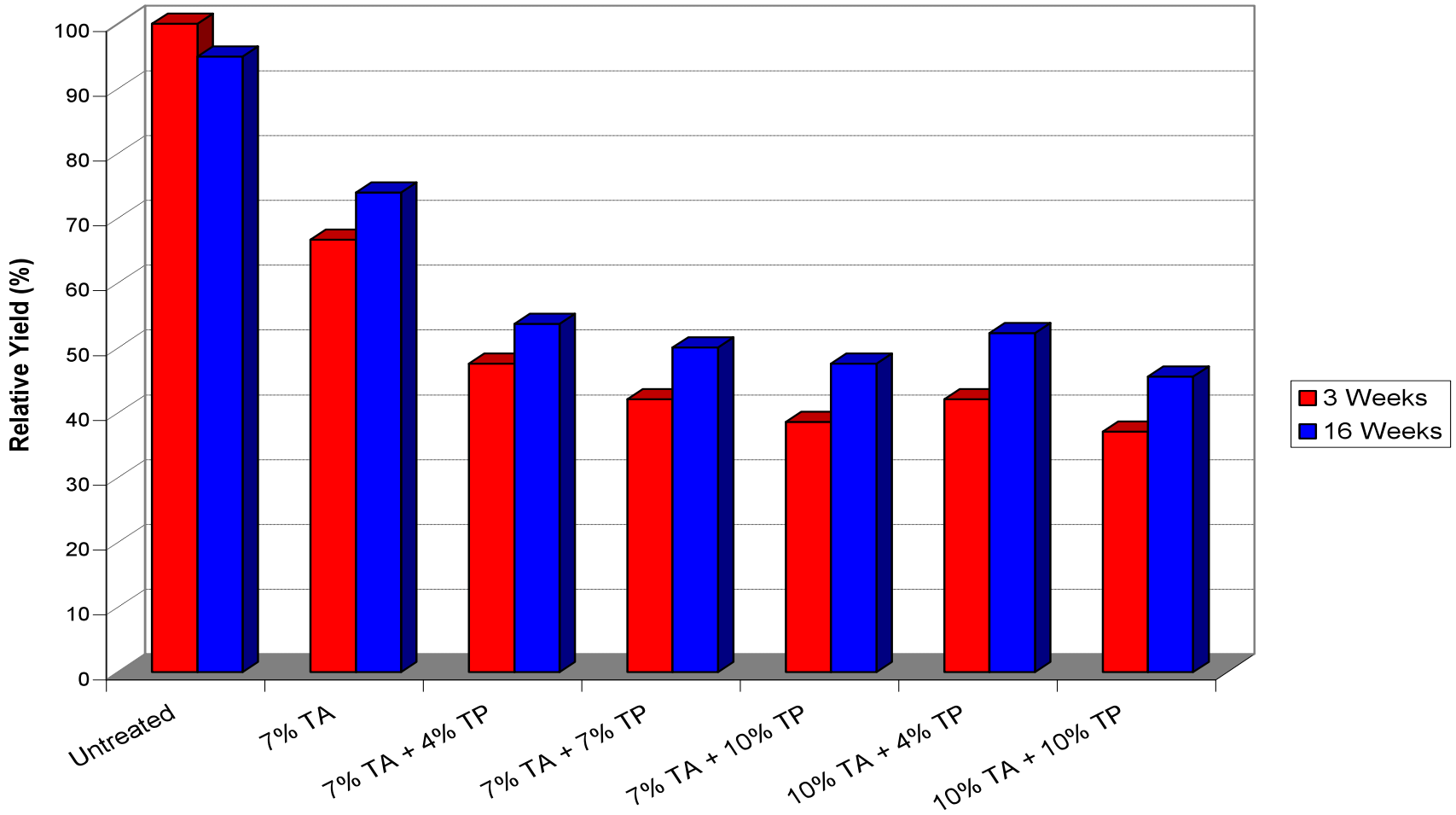
Relative Monohydroxy Phenol Yields as Function of Age and Additive



Machine-made Filter Trials - 2

- The previous set of trials carried out on machine made filters identified tripropionin as the most effective additive
- A further set of machine-made filter trials was carried out using different quantities of triacetin and tripropionin:
  - *Untreated*
  - *7% triacetin*
  - *7% triacetin AND 4%, 7% or 10% tripropionin*
  - *10% triacetin AND 4% or 10% tripropionin*
- Yields of phenols were tested after filter cigarettes had been aged for 3 and 16 weeks
- Results for mono hydroxy phenols given in following slide

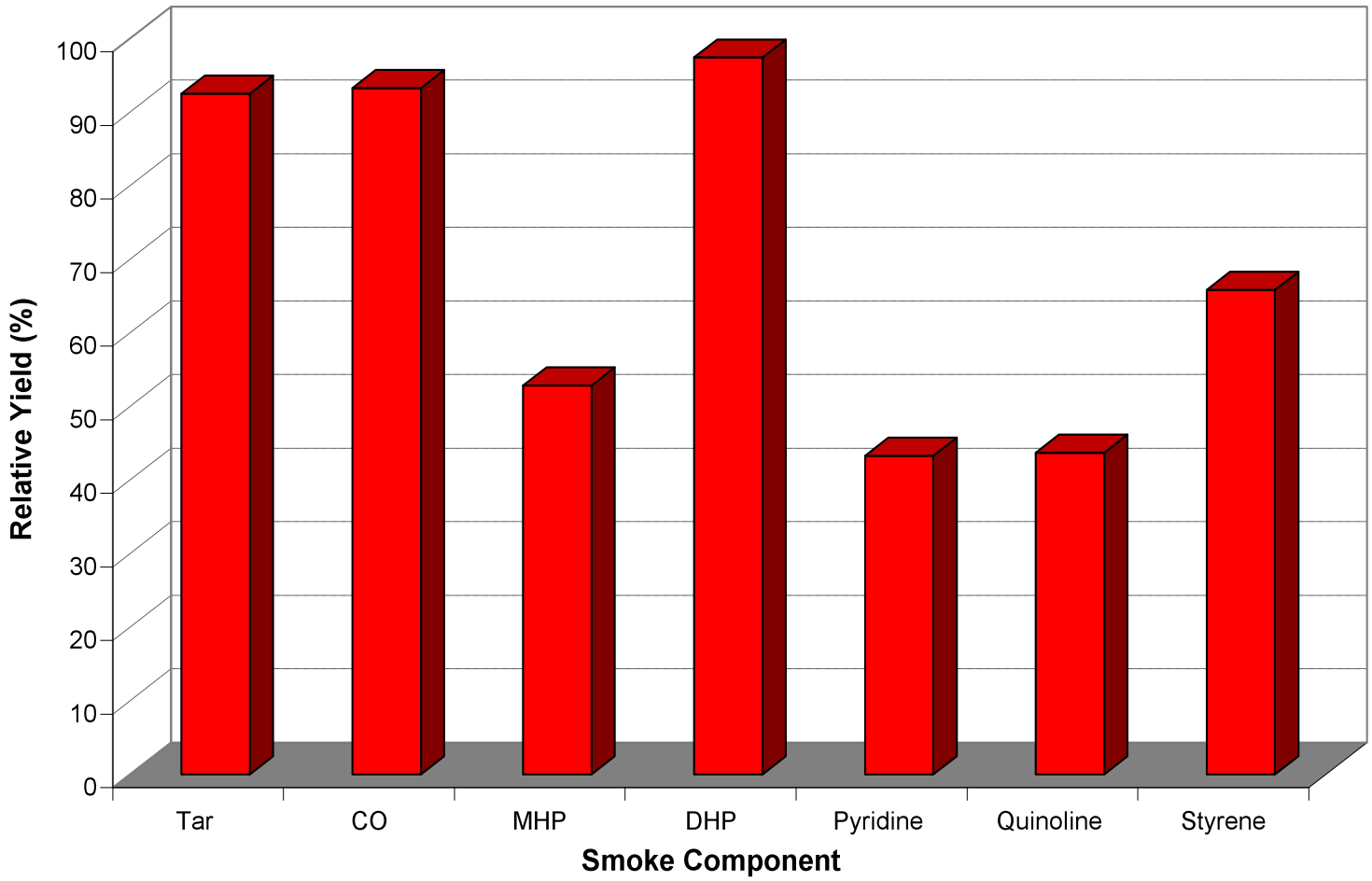
Relative MHP Yields at Different Loadings of Triacetin and Tripropionin



Proving Trials

- One of the applications envisaged for this material is for low CO:Tar cigarettes that are highly ventilated with low retention filters, e.g. “COR” filters
- Such cigarettes tend to give an increase in MHP due to the lower quantity of cellulose acetate used in the filter
- Two products of this type were manufactured
  - 7% triacetin level in filter
  - 7% triacetin + 10% tripropionin in filter
- No manufacturing problems encountered
- Cigarettes were tested for numerous smoke constituent yields, including
  - Tar, nicotine and CO
  - Monohydroxy and dihydroxy phenols
  - Pyridine, quinoline and styrene

Relative Yields using ‘COR’ Filter with 10% Tripropionin



Carbon Filters

- Our studies showed that tripropionin was effective in reducing phenols in cellulose acetate filters
- Carbon filters were also tested in which tripropionin was added to the filter material
- However, no enhanced reduction of phenols was observed for carbon filters with tripropropionin
- The vapour phase removal efficiency of these filters was also adversely affected by the addition of tripropionin
- Other solutions would be required to enhance the reduction of phenols by carbon filters

Conclusions

- A screening exercise has shown that tripropionin is a highly effective additive for enhancing the reduction of phenols by cellulose acetate filters
- As expected, there was no effect on those phenolic compounds that are not available for selective filtration.
- Tripropionin exhibited a mild plasticizing effect on cellulose acetate, but was best used in combination with triacetin
- There were no adverse effects on filter processing from the inclusion of tripropionin
- No beneficial effects on phenol reduction were observed when tripropionin was used in paper or carbon filters
- Significant reductions in pyridine, quinoline and styrene yields were also observed using CA filters with tripropionin

Thank you for your attention