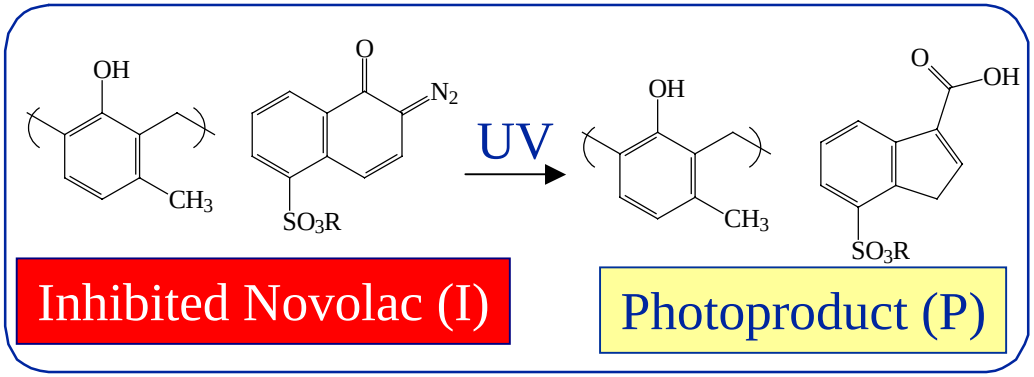
Dissolution Inhibitors for 157 nm Photolithography

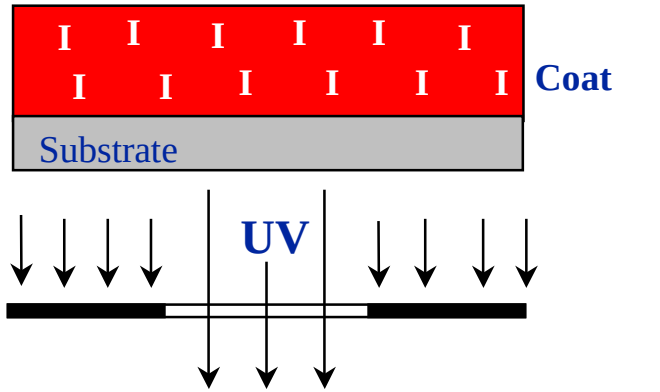
Charles Chambers[a], Shiro Kusumoto[a], GeunSu Lee[b], Alok Vasudev[a], Leonidas Walthal[a], Brian Trinque[a], Brian Osborn[a], Yu-Tsai Hsieh[a], Takashi Chiba[a], Paul Zimmerman[b], Daniel Miller[b], Willard Conley[b], Grant Willson[a]

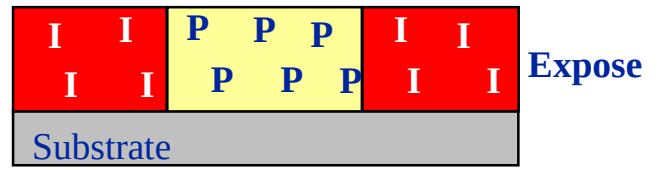
[a]Department of Chemistry
University of Texas, Austin, TX USA

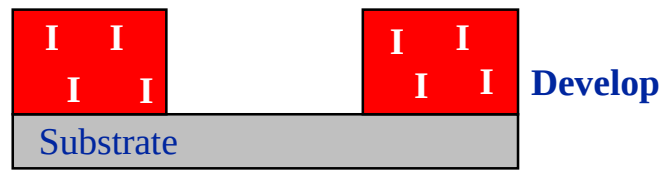
[b]International SEMATECH,
Austin, Texas USA

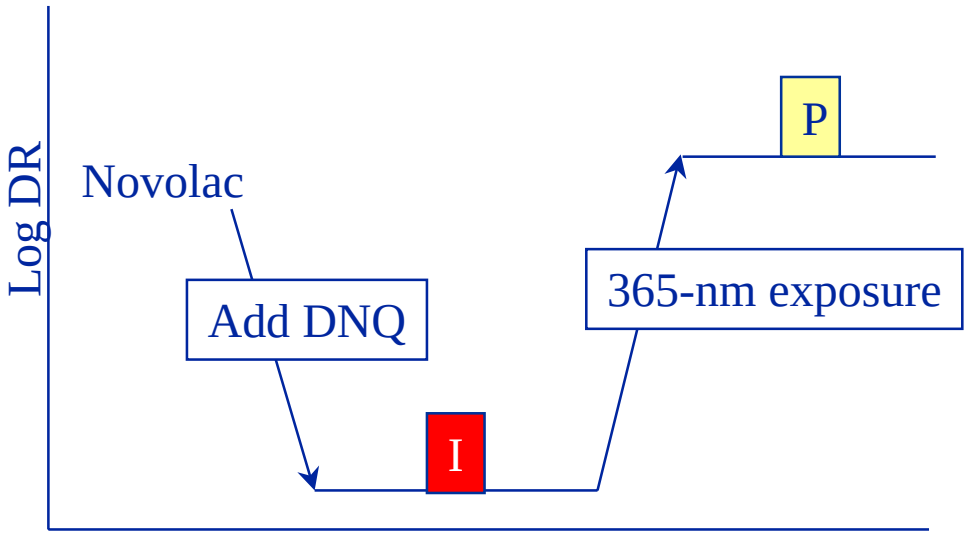
Novolac/DNQ Photoresists



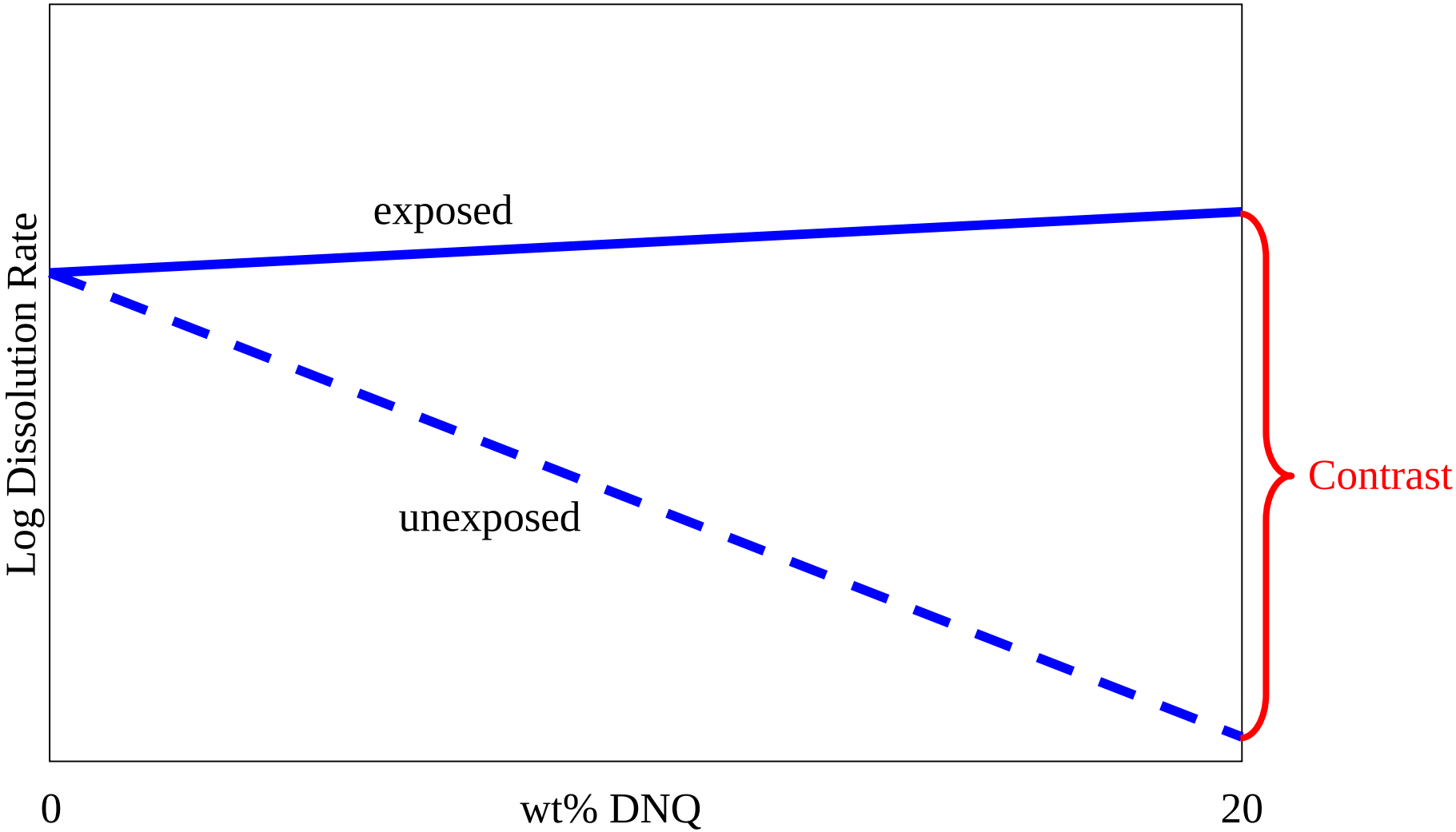






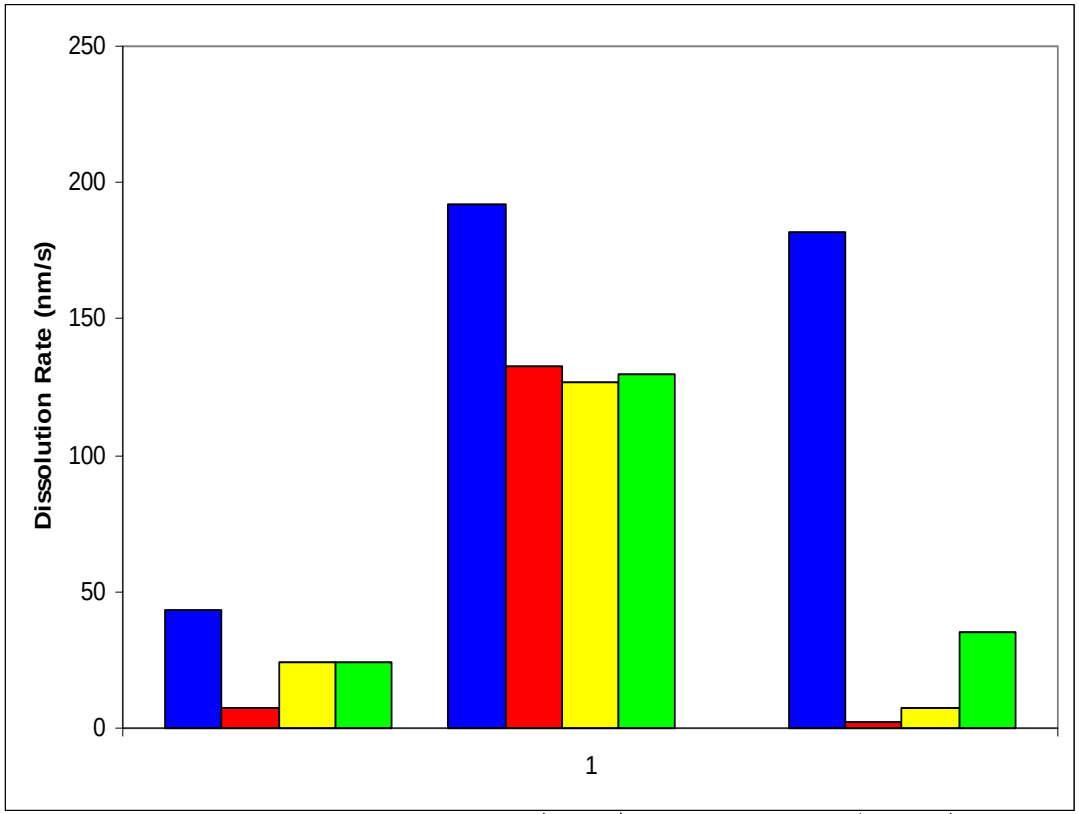


Meyerhofer Plot

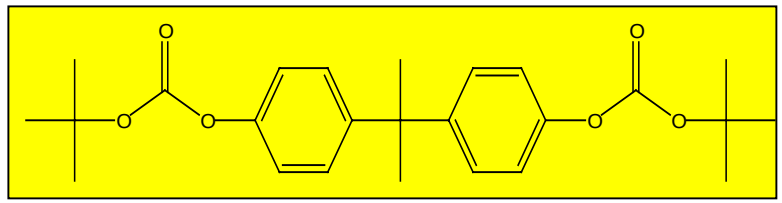


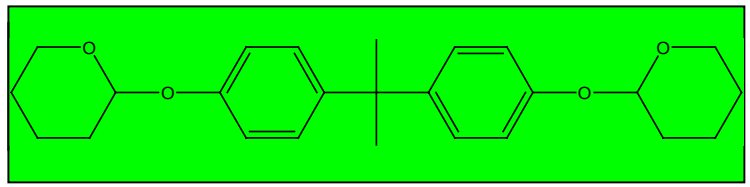
$$\text{Contrast} = \text{Log DR}_{exp} - \text{Log DR}_{unexp}$$

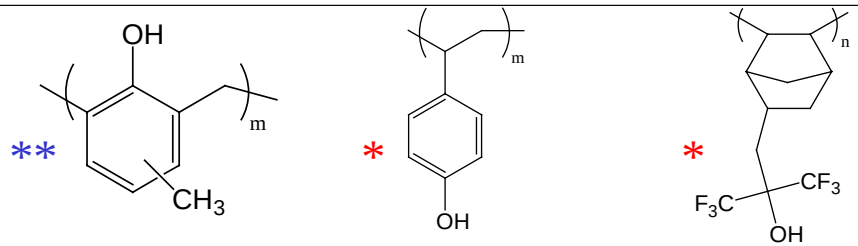
Functional Group Inhibition Study



Resin Only





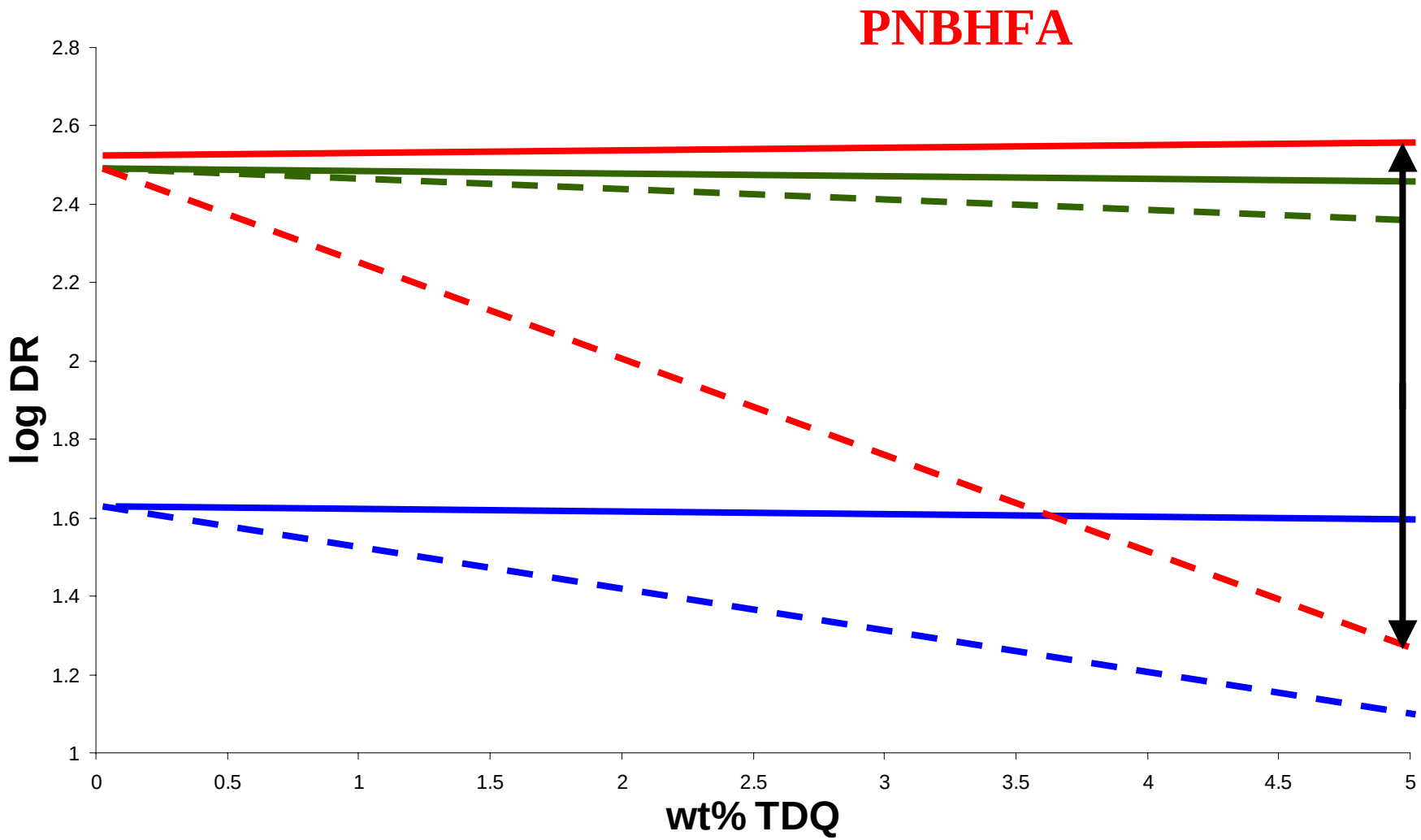


* Dissolution rates (nm/sec) measured using 0.22 N TMAH

** Dissolution rates (nm/sec)measured using 0.26 N TMAH

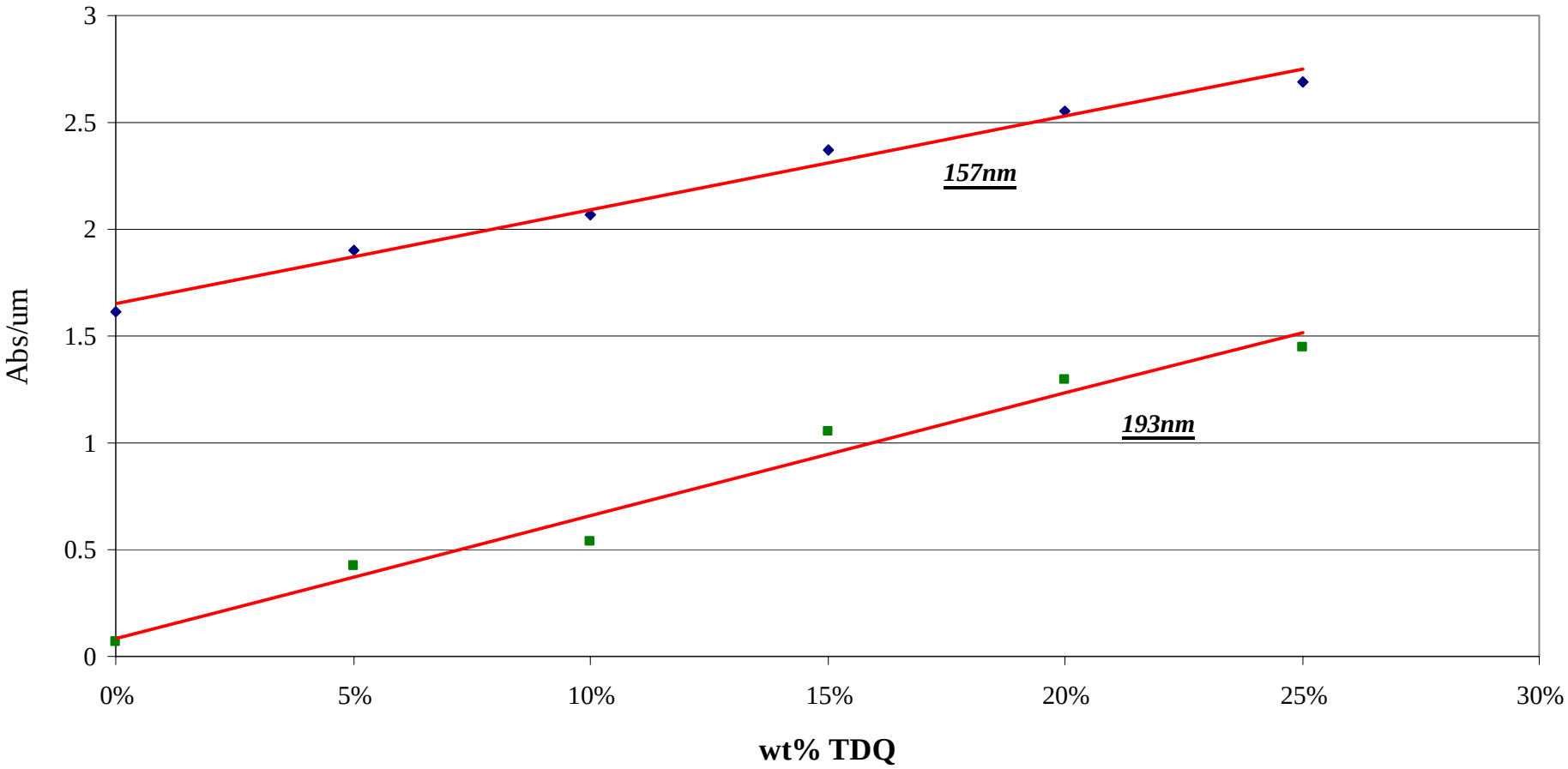
Molar equivalents to 5 wt % TDQ were used for other DIs

PNBHFA has an absorbances of 1.14 μm^{-1} at 157 nm



Nov-TDQ- The classic but opaque below about 300 nm
PHS-TDQ- Transparent in the DUV but no inhibition
PNBHFA-TDQ- Transparent and GREAT inhibition!

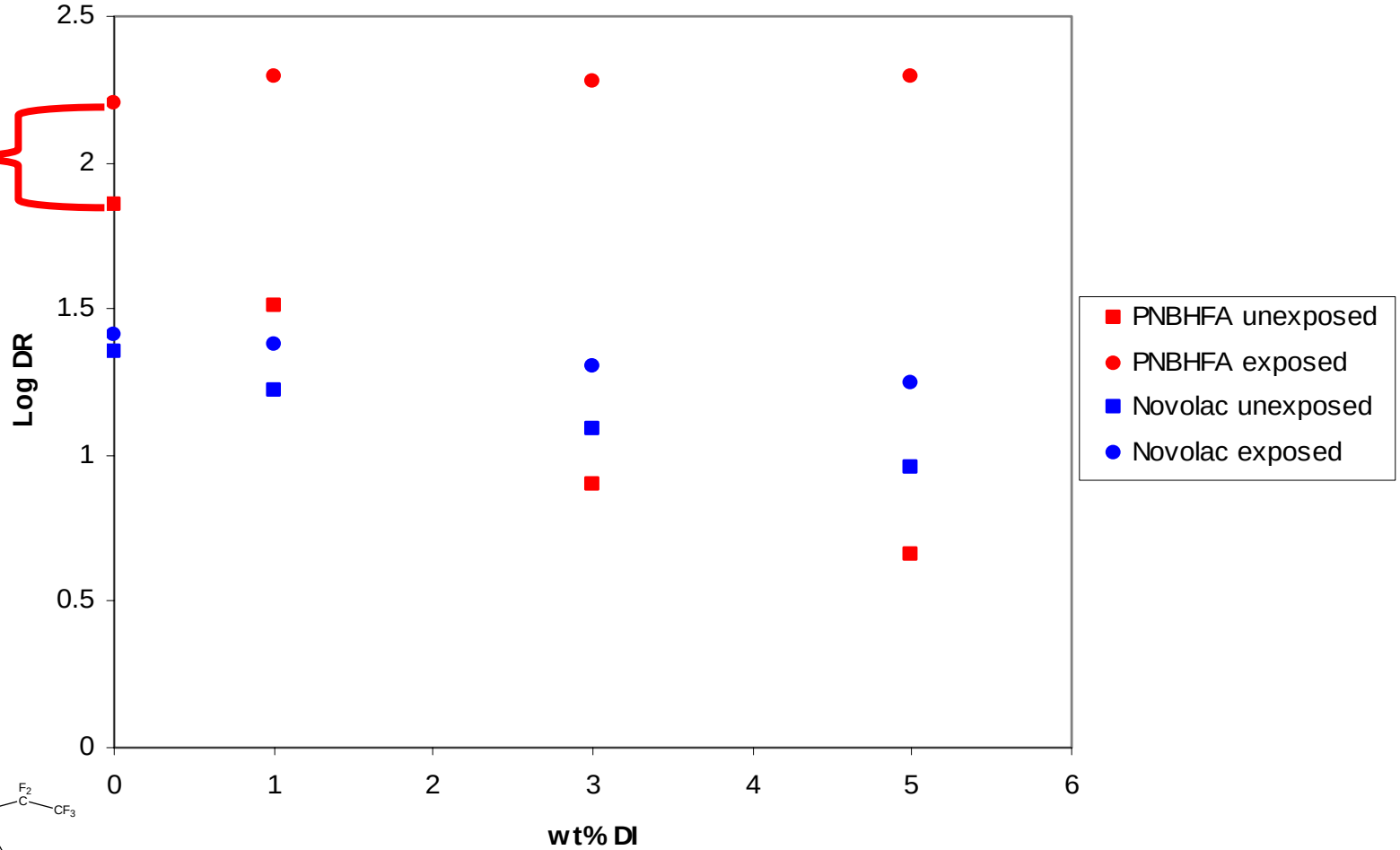
Absorbance vs wt% TDQ in PNBHFA

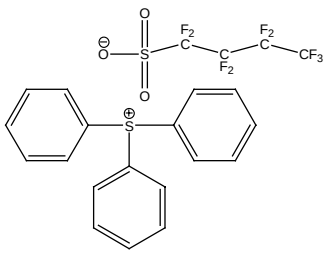


TDQ is too opaque for at 157 nm

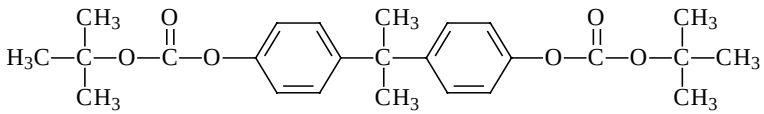
Meyerhofer Plot of Bis-Boc Bisphenol A with 1 wt% TPSNf

PAG effect



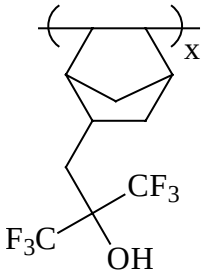


TPSNf

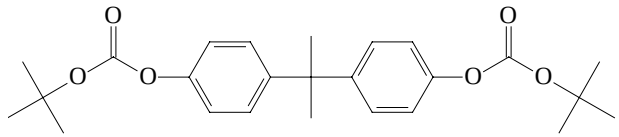


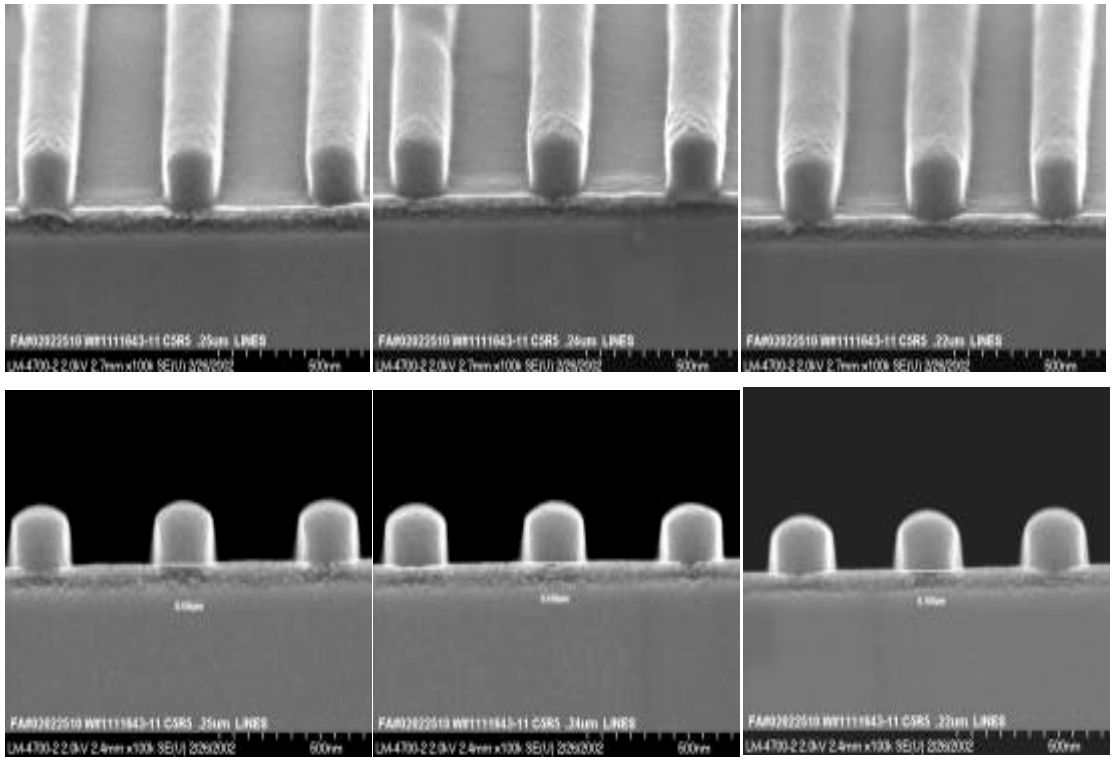
Bis-BOC-Bisphenol A

248nm Exposure



10 wt%

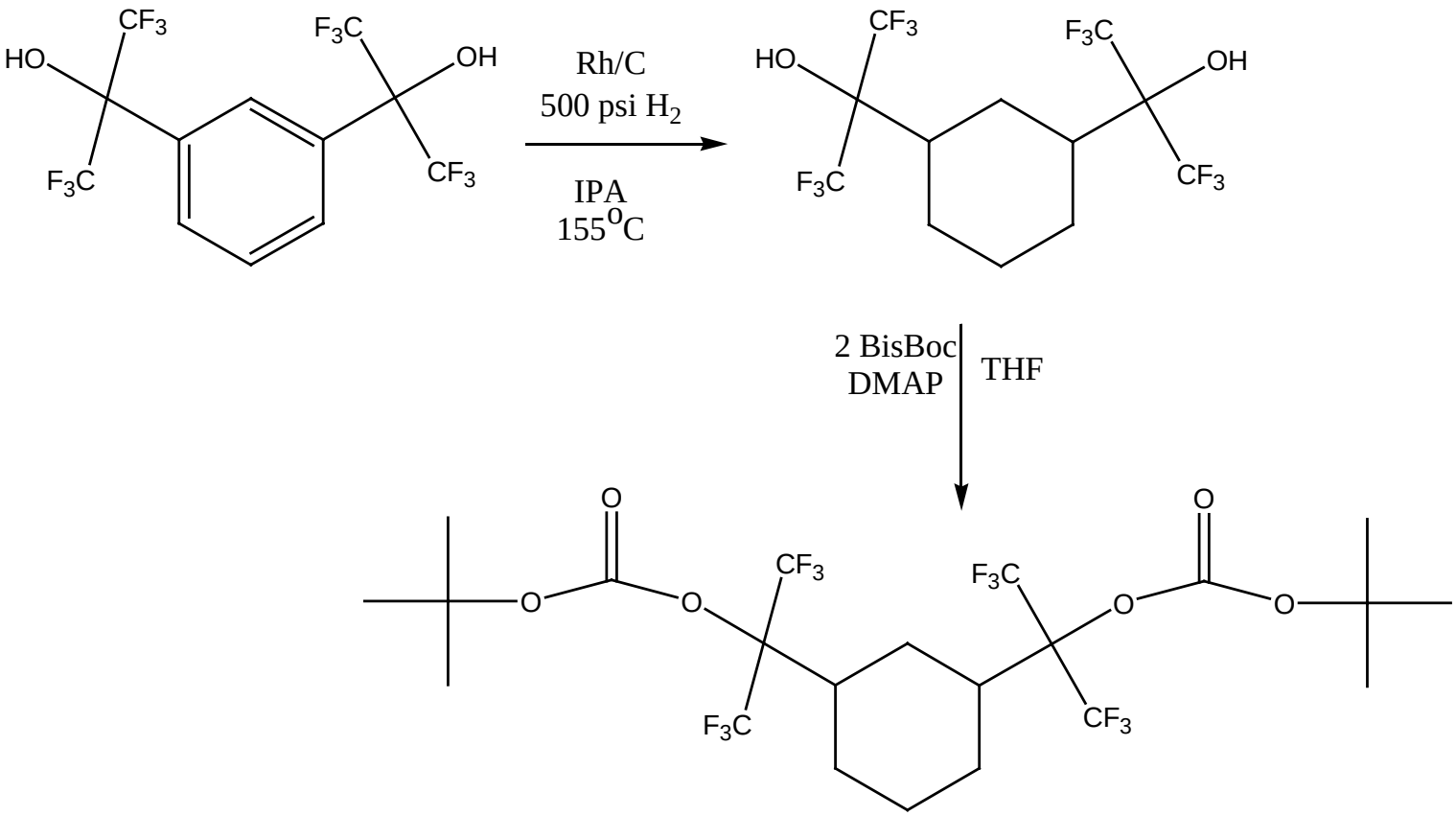




133nm thick

250nm **240nm** **220nm**

Synthesis of a transparent *tert*-Butyl Carbonate Based DI for 157 nm



Maruno, T.; Nakamura, K.; Murata, N. *Macromolecules*, **1996**, 29, 2006-2010.

85% NBHFA + 15% 1,3 Bis Boc

157nm Exposure 100nm Cross section

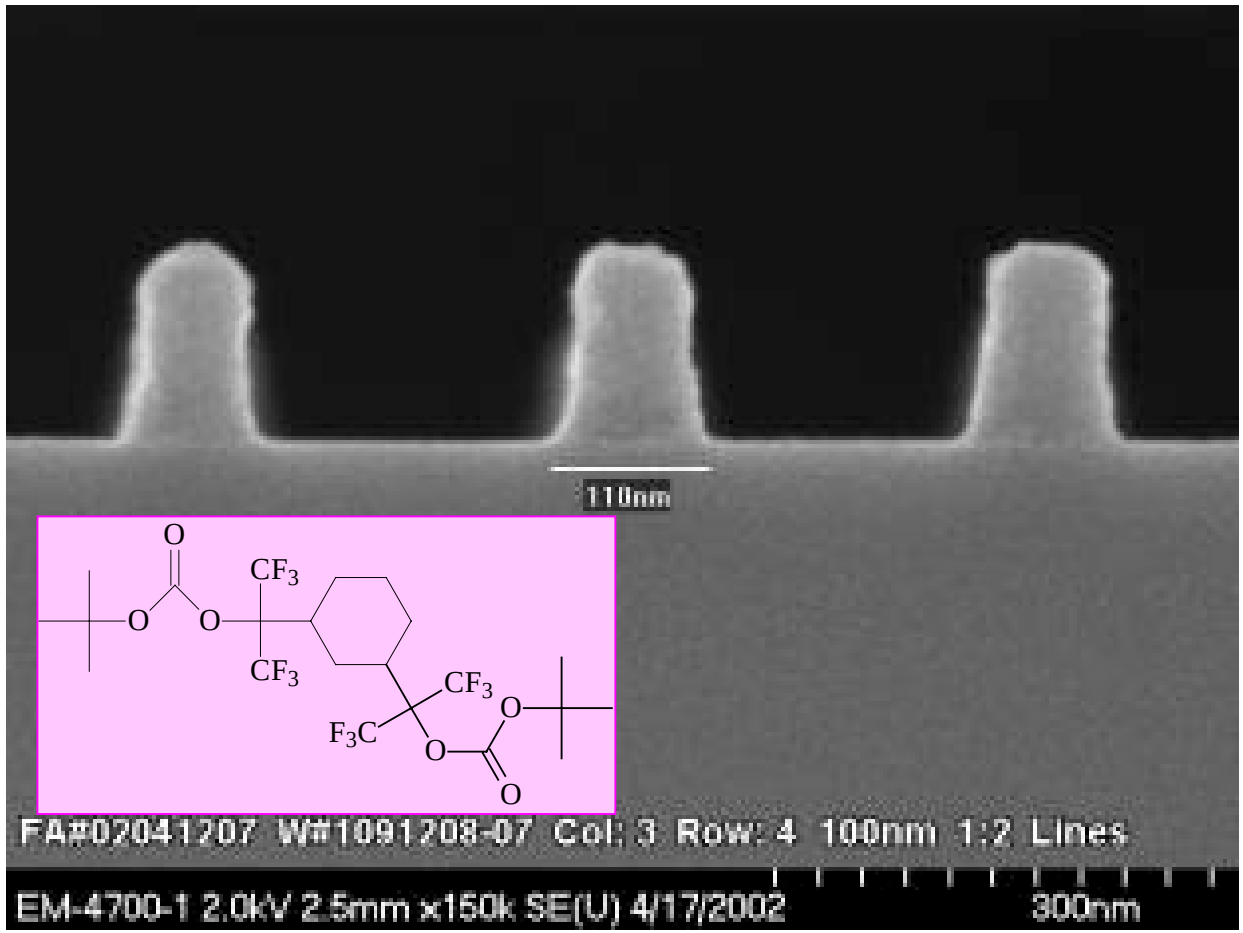
PAB: 90C/60s

PEB: 80C/90s

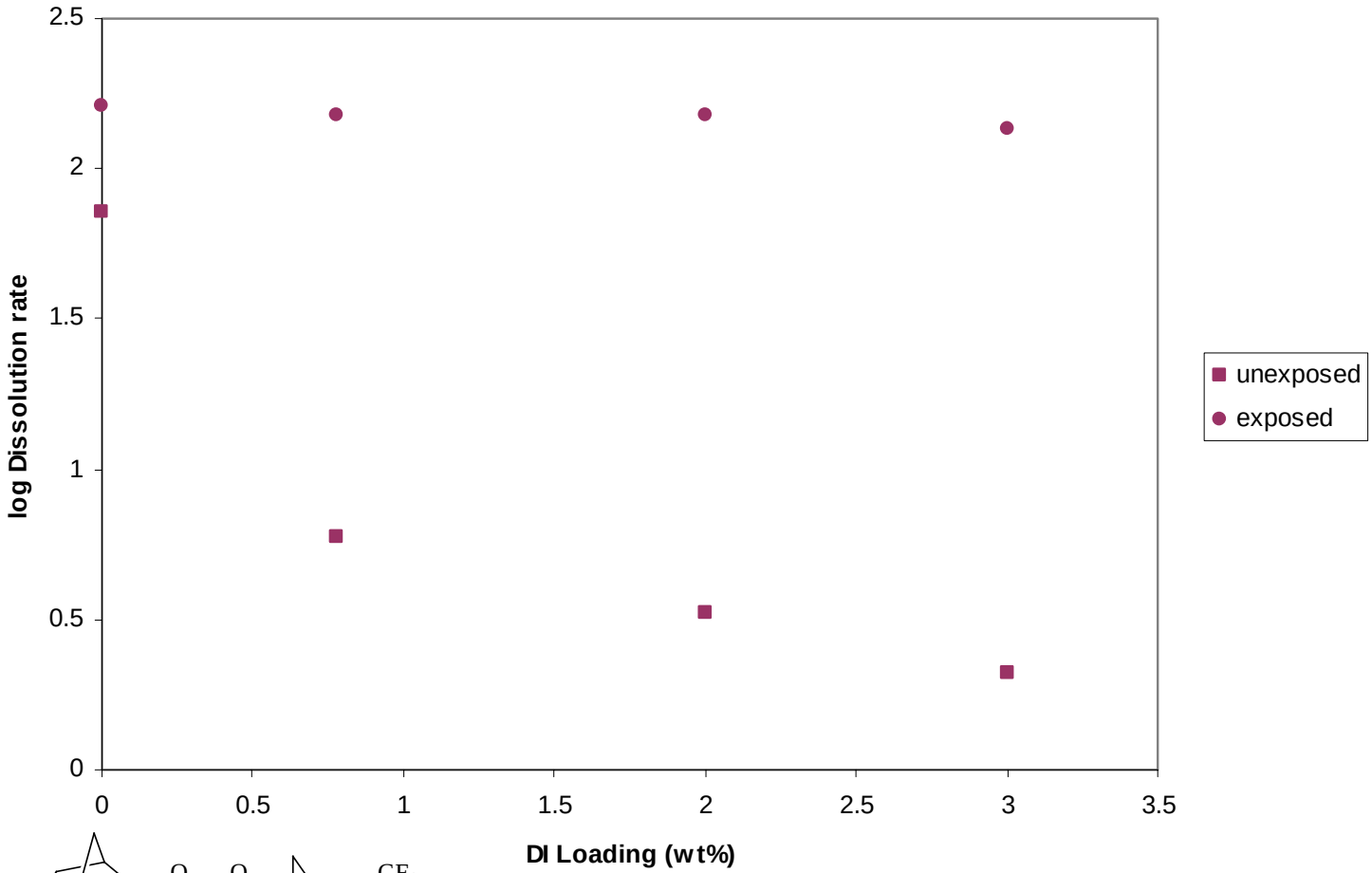
DEV:20s LDD26

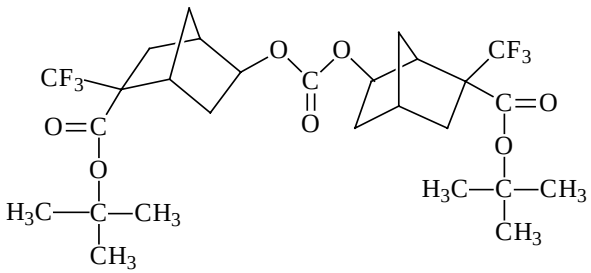
1840 A

18.6 mJ/cm^2

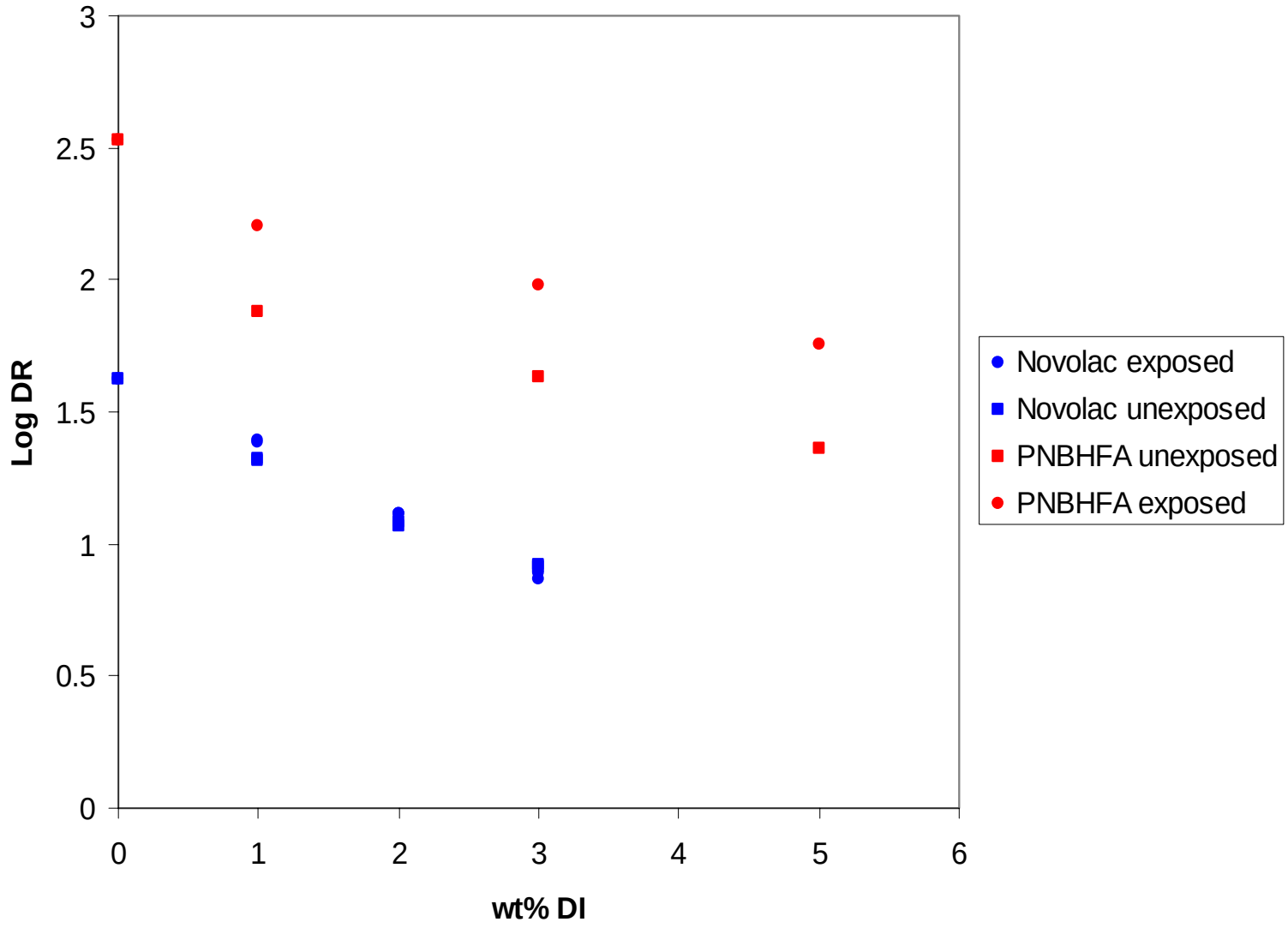


Meyerhofer Plot of New DI in PNBHFA + 1 wt% TPSNf

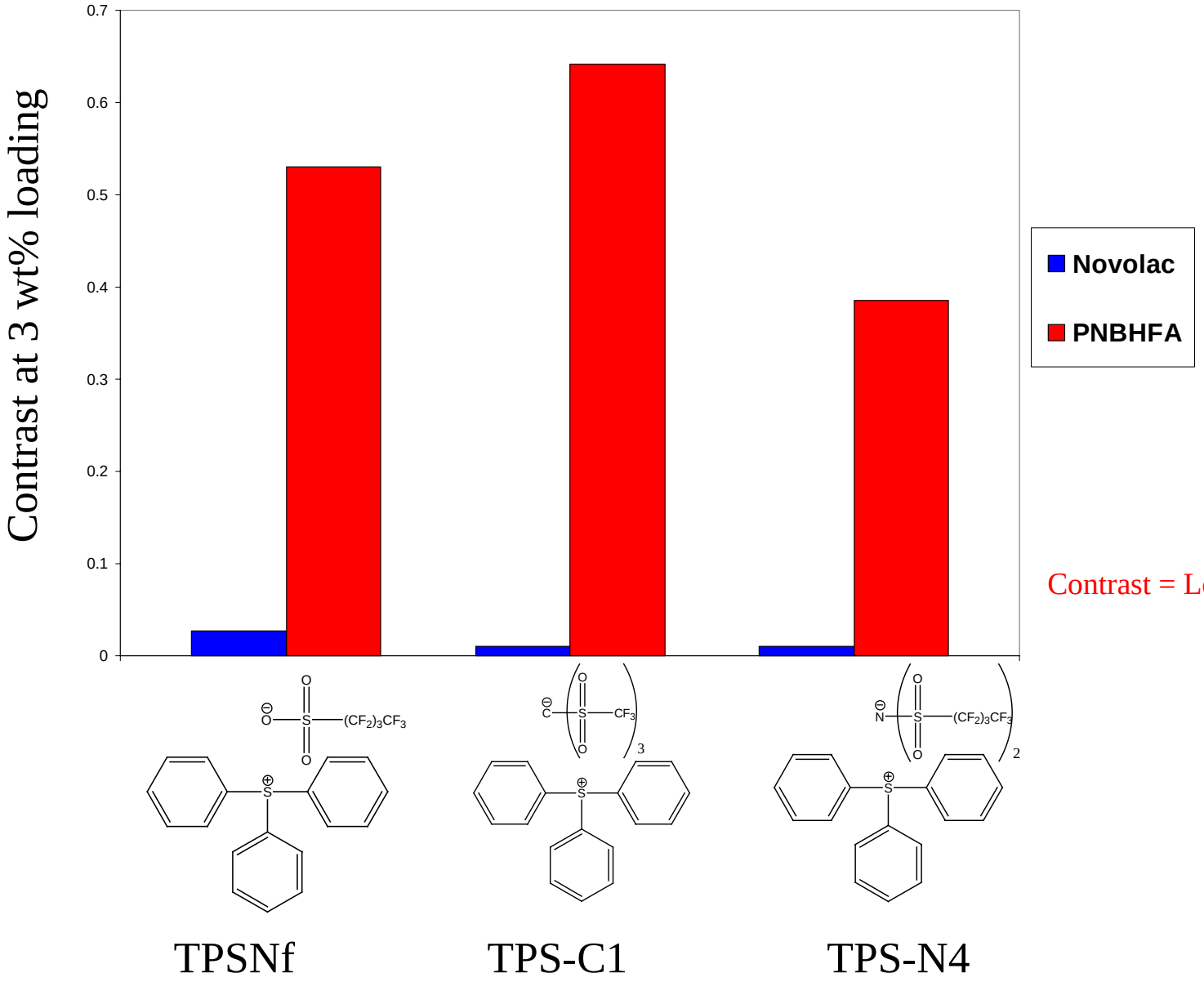




Meyerhofer Plot of TPSNf

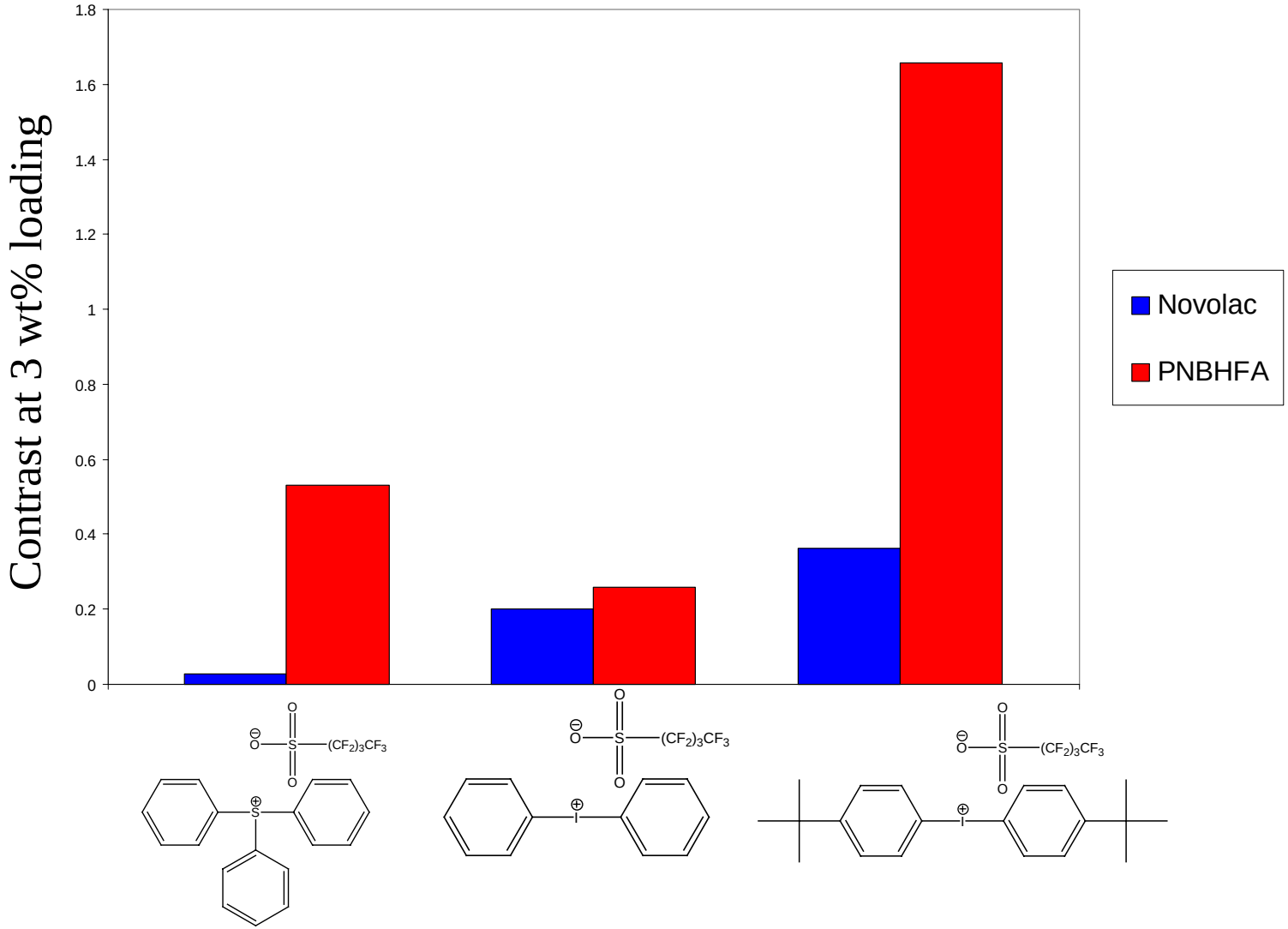


Triphenyl Sulphonium PAG With Different Counter Ions

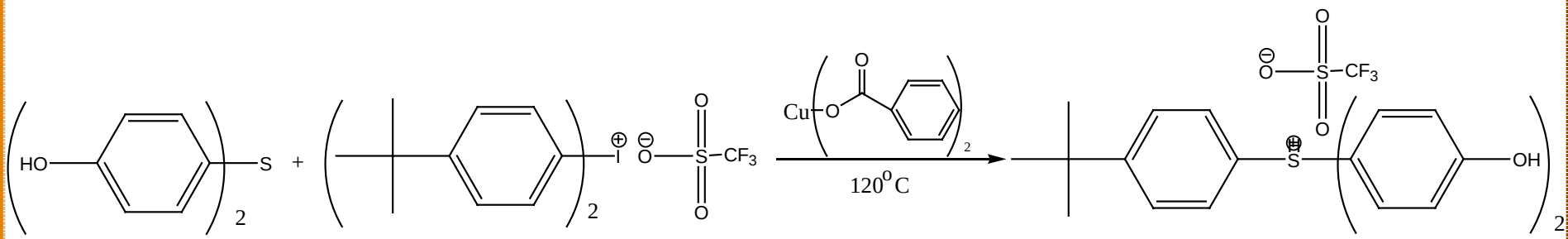


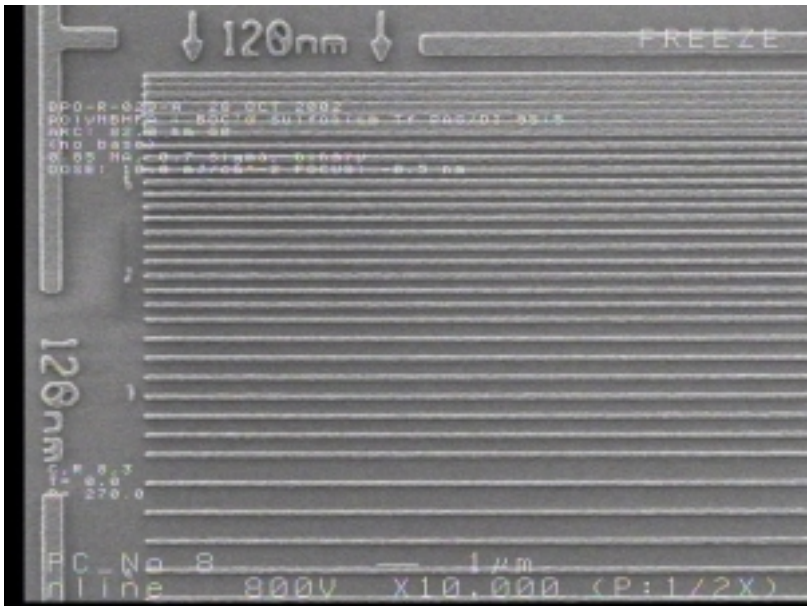
Contrast = Log DR_{exp} – Log DR_{unexp}

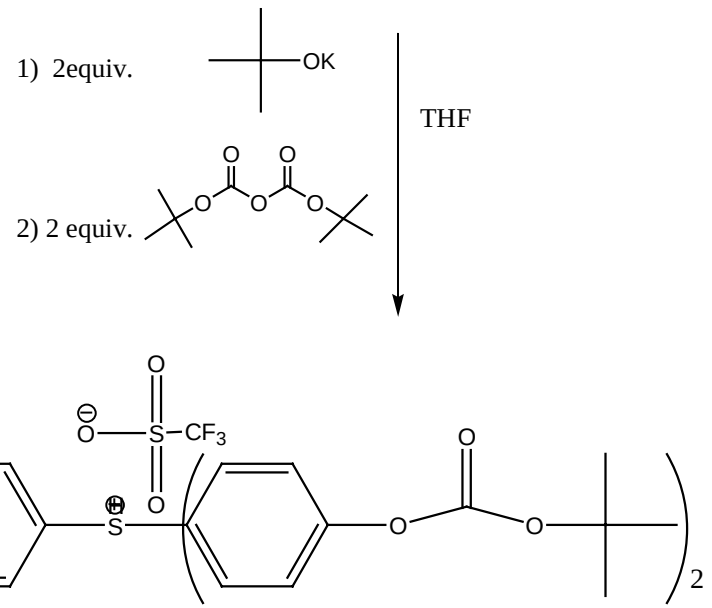
Nonaflates With Different PAGs



Synthesis of PAGs with Better Contrast



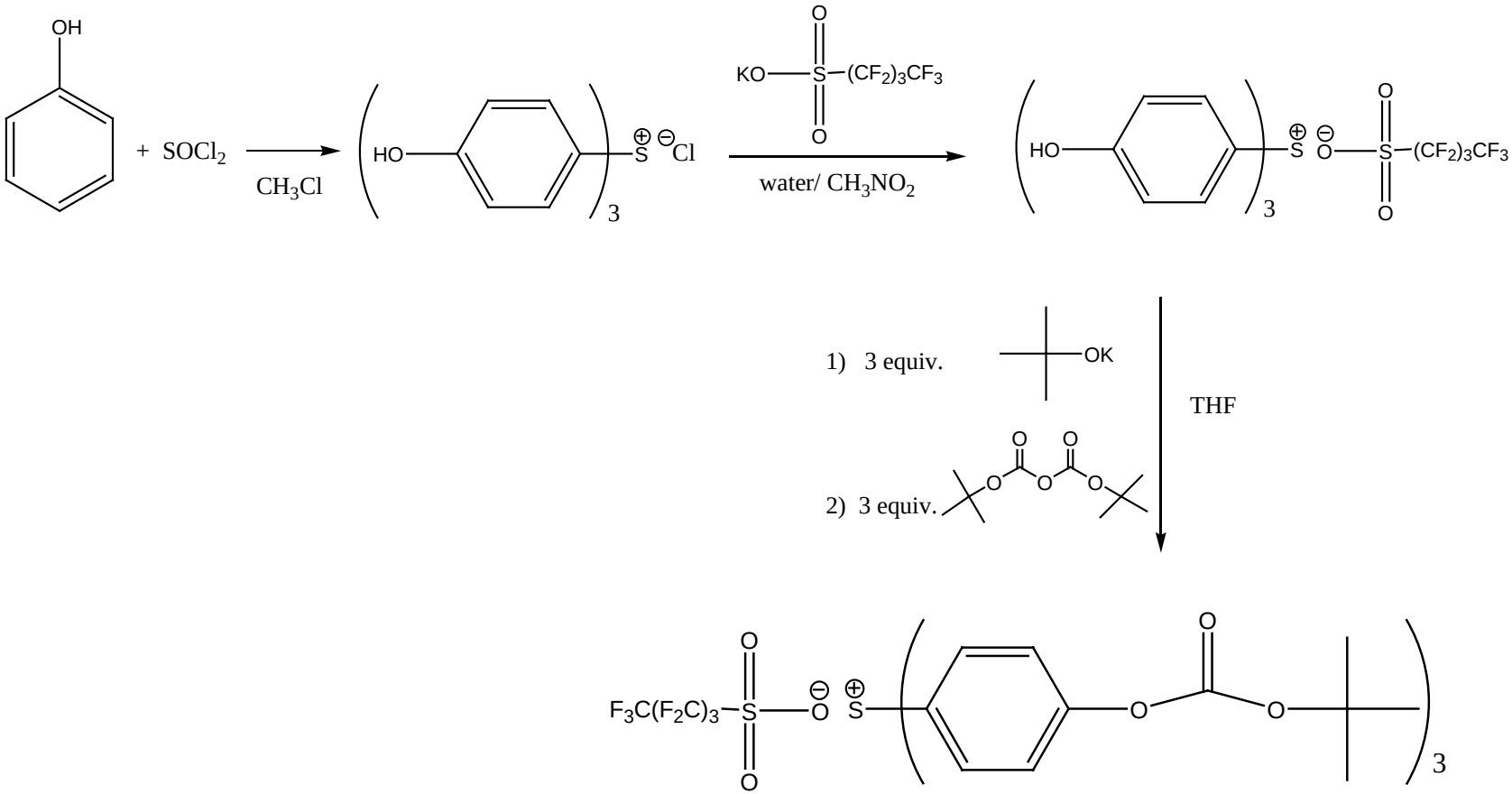




Crivello, J. V., Lam, J. H. W. *J. Org. Chem.*, Vol. 43, No. 15, **1978,** 3055-30058**.**

Schwalm, R. et all. *J. Chem. Soc. Perkin Trans 2*. **1991**, 1803-1808.

Synthesis of PAGs with Better Contrast



Conclusions

Three component system design shows great promise

- Backwards compatibility to 193 and 248!!
- Ease of formulation should speed development

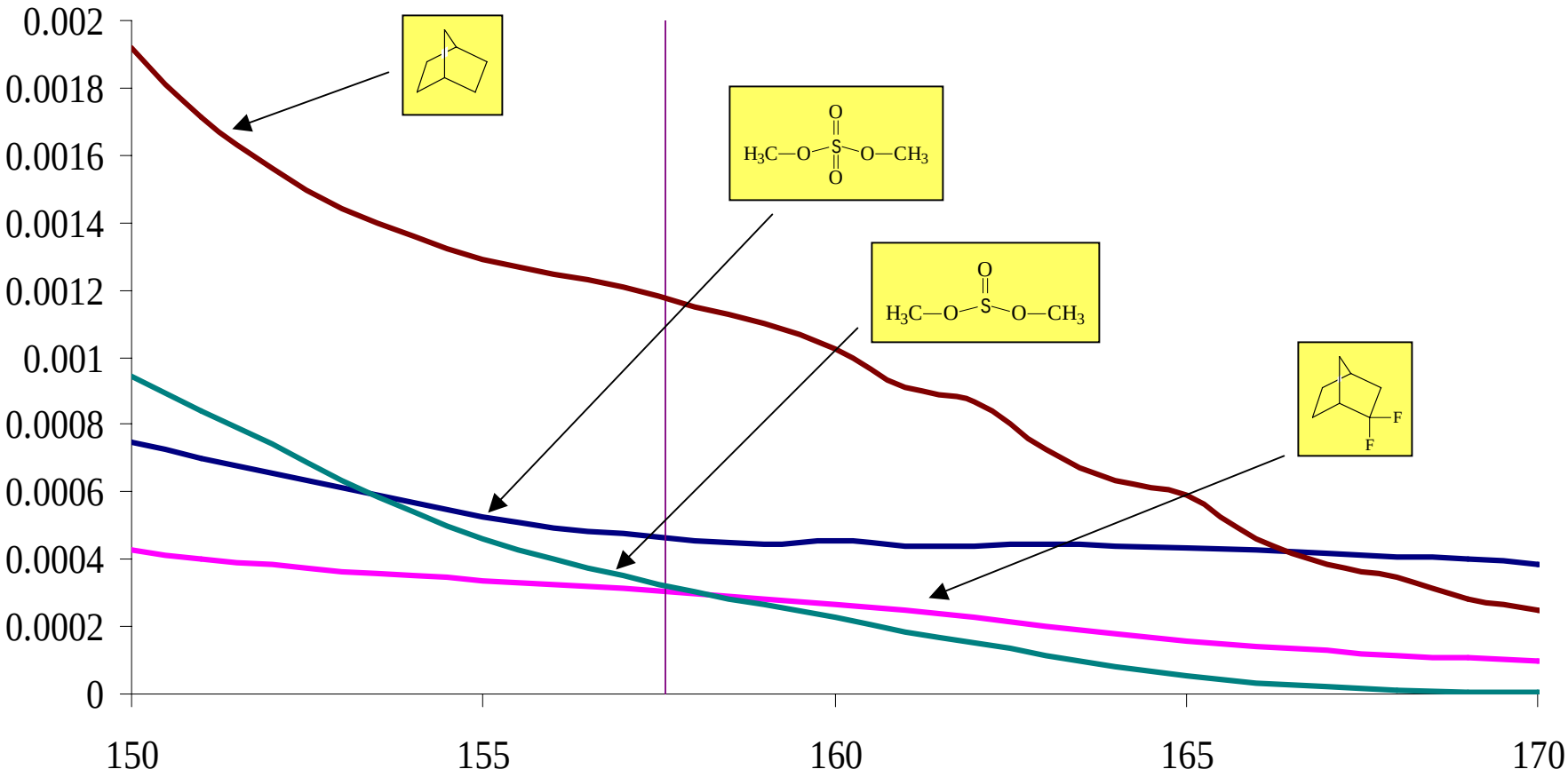
Two component system with PAGs acting as DIs is possible

- All PAGs tested effected the dissolution rate of PNBHFA and Novolac
- Slight structural modifications can greatly effect dissolution inhibition properties of PAGs

Future Work

- Continue work on DIs for 3 component system
- Test dissolution inhibition of other commercial PAGs
- Synthesis and test functionalized PAGs

Gas Phase Absorbance Data



- Surprising transparency of sulfur compounds

Acknowledgements

SEMATECH: Vicki Graffenberg,

Shashikant Patel, Mike Rodriguez

AZ Clariant: Ralph Dammel

3M

Central Glass Co.

JSR

Eternal

Hynix Semiconductor, Inc

BASF: Reinhold Schwalm

Willson Research Group