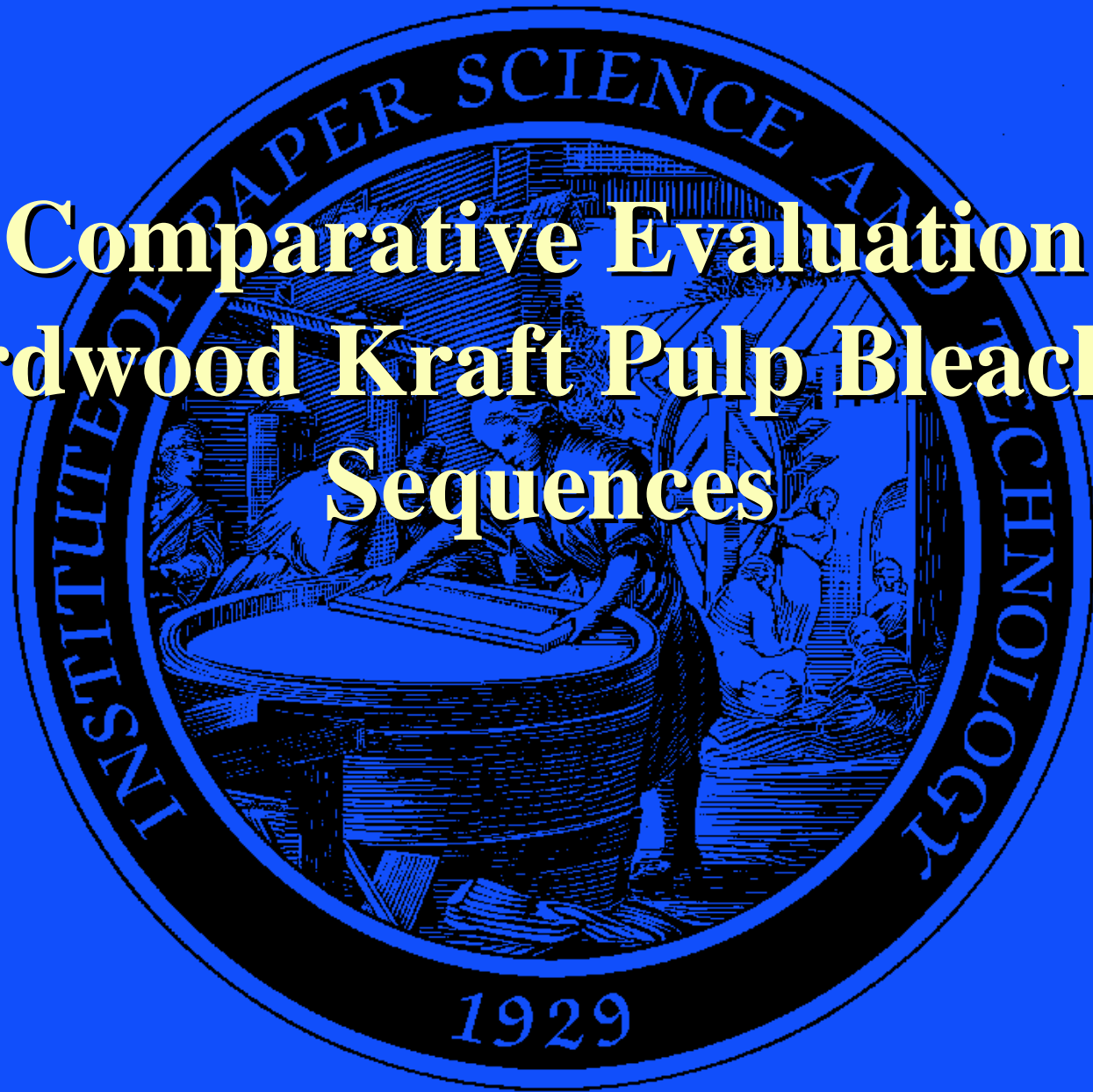


A Comparative Evaluation of Hardwood Kraft Pulp Bleaching Sequences



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Sequences

- (DC)(EPO)DED
- D(EPO)DED
- (D/Z)(EPO)DED
- OD(EPO)D
- OD(EPO)DD
- OD(EPO)DP
- OD(EPO)DZ
- O(Z/D)(EPO)DP

Furnish and Conditions

- Southern U.S. hardwood kraft
- Brownstock kappa 13
- Oxygen delignified kappa 9.3
- Black liquor (10 kg BLS/t) in first stage and filtrate carryover in other stages (10% from D_0 , 20% from other stages)
- Kappa factor 0.20
- Consistency 3.5% for D_0 , (D/C), (D/Z) and (Z/D), 32% for final Z, 10% all others

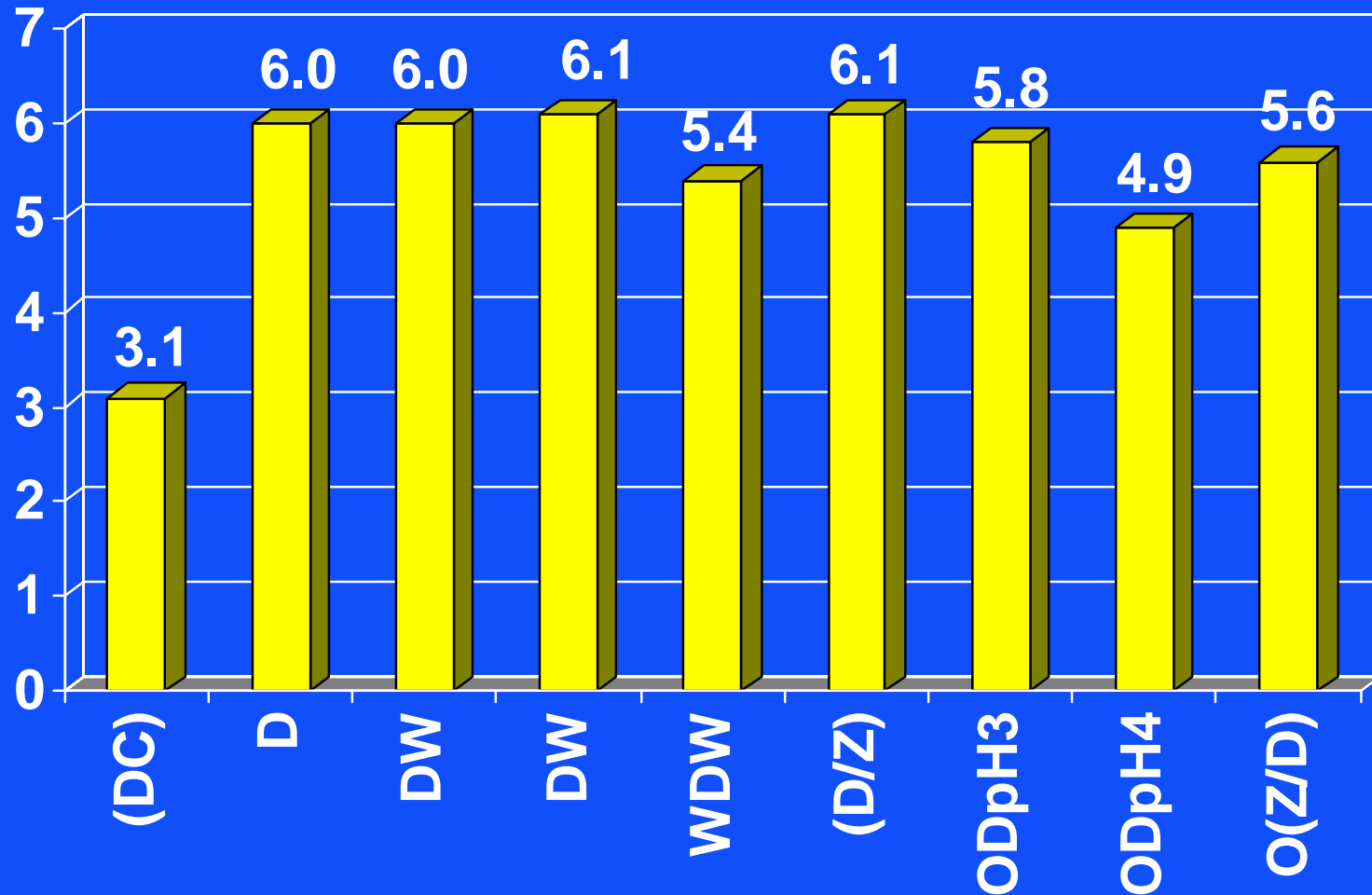
Delignification Partial Sequences

Delignification Partial Sequences

- (DC)(EPO)
- D(EPO)
- DW(EPO)
- WDW(EPO)
- (D/Z)(EPO)
- OD₃(EPO)
- OD₄(EPO)
- O(Z/D)(EPO)

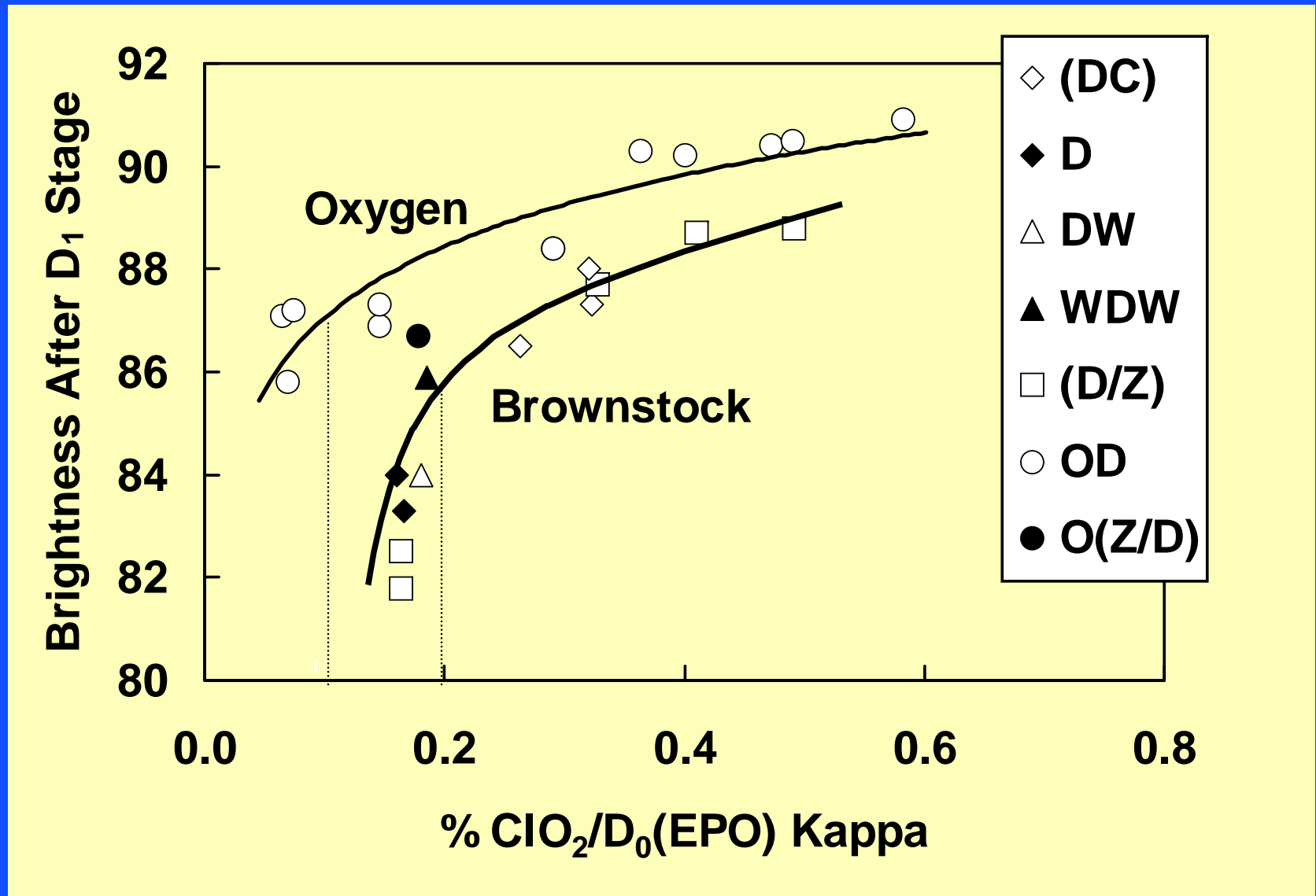
W = Perfect wash

Kappa After S(EPO) and OS(EPO)



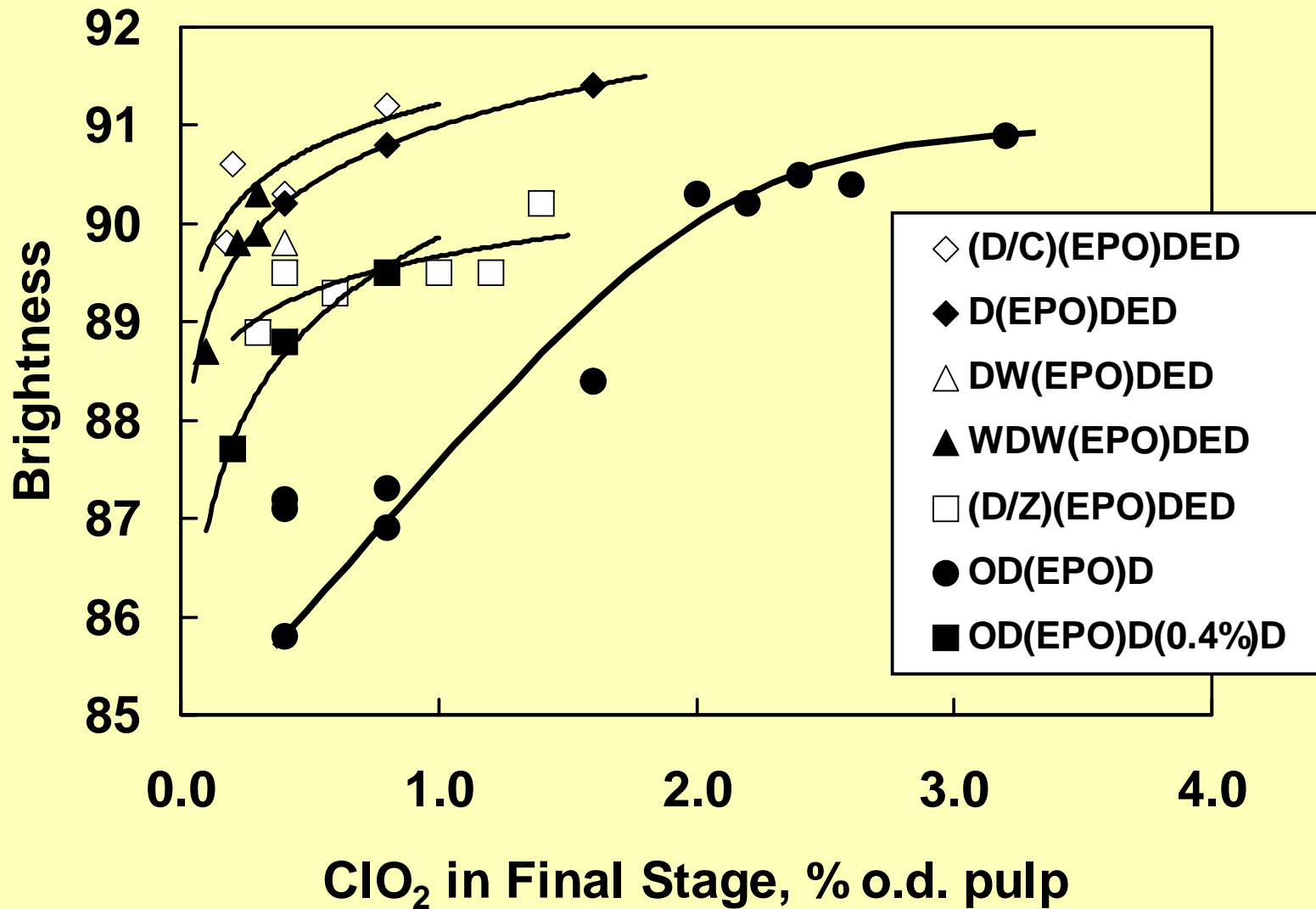
Initial Brightening

S(EPO)D₁ Brightness vs ClO₂ Ratio

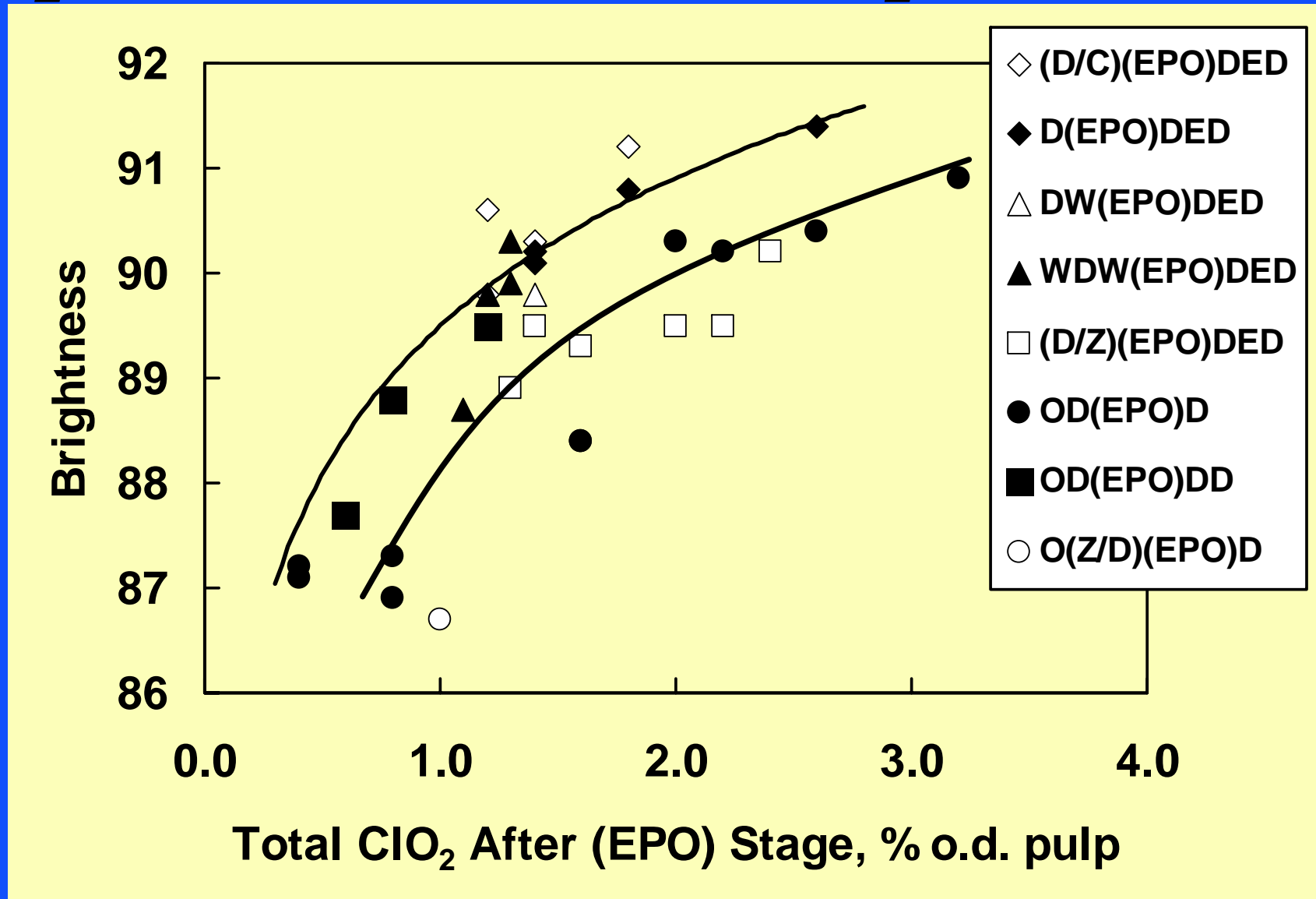


Final Brightening

D₂ Brightness vs ClO₂ in D₂

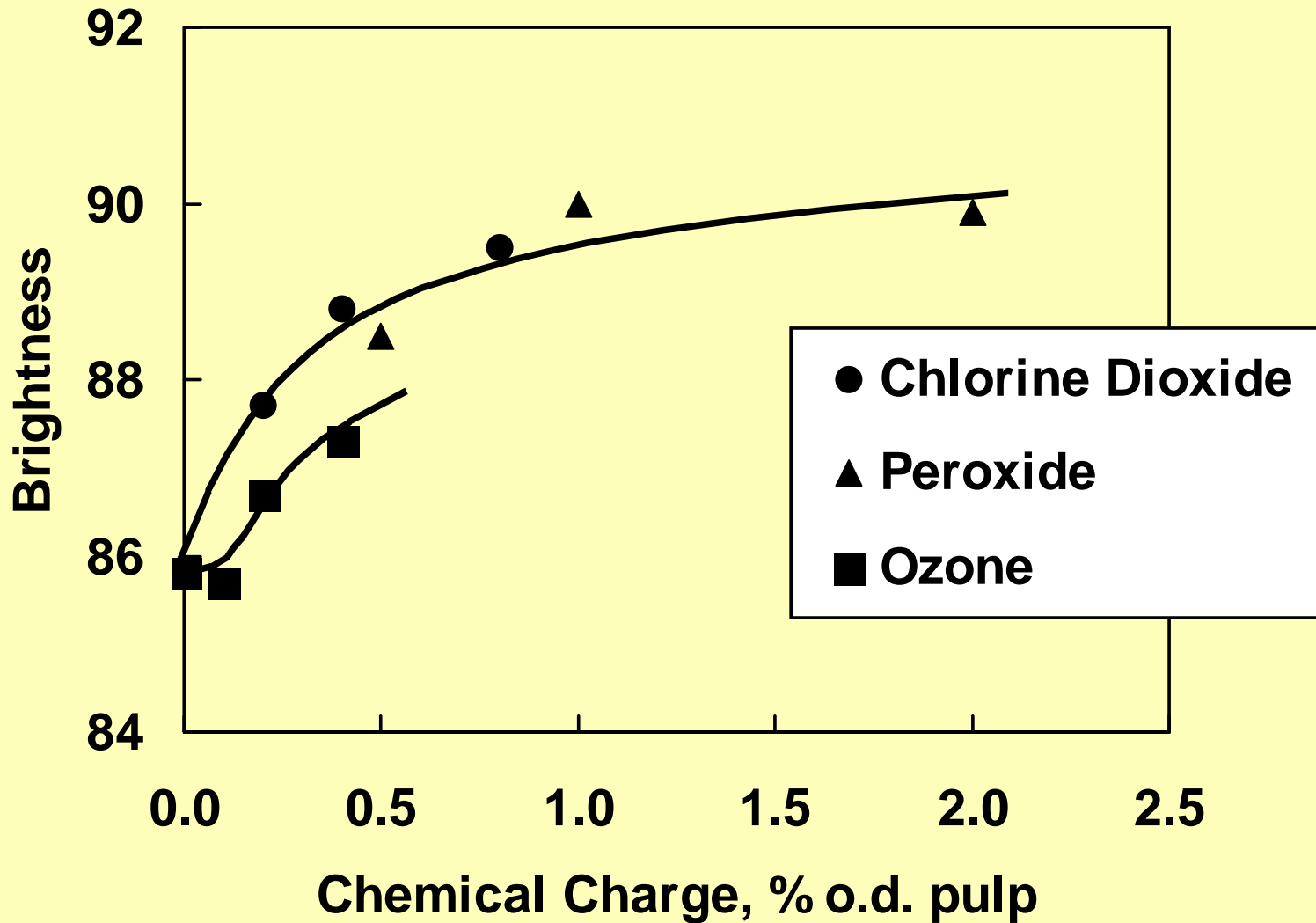


D₂ Bright. vs Total ClO₂ After (EPO)

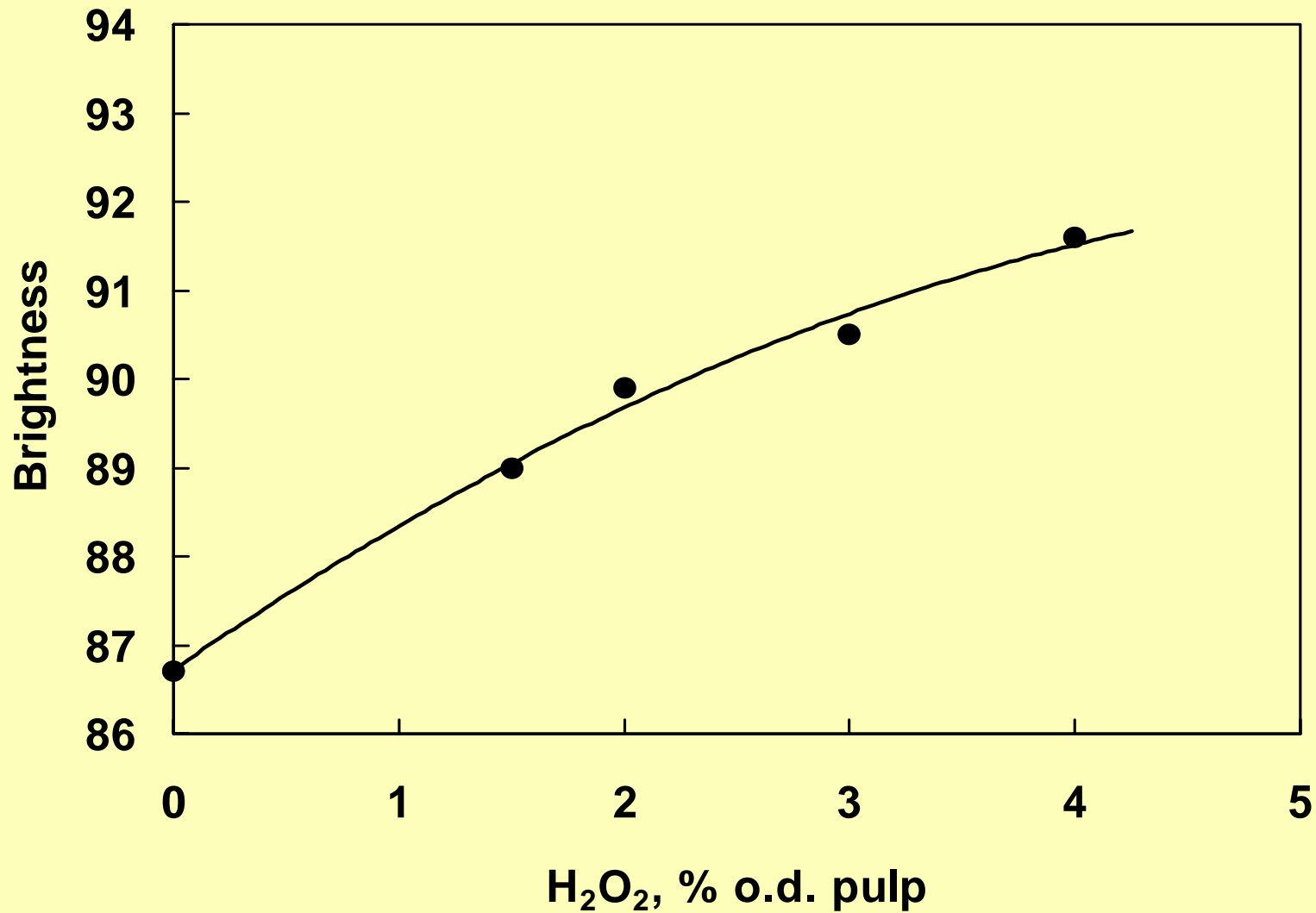


Hydrogen Peroxide and Ozone as Final Brightening Stages

Brightening After OD(EPO)D

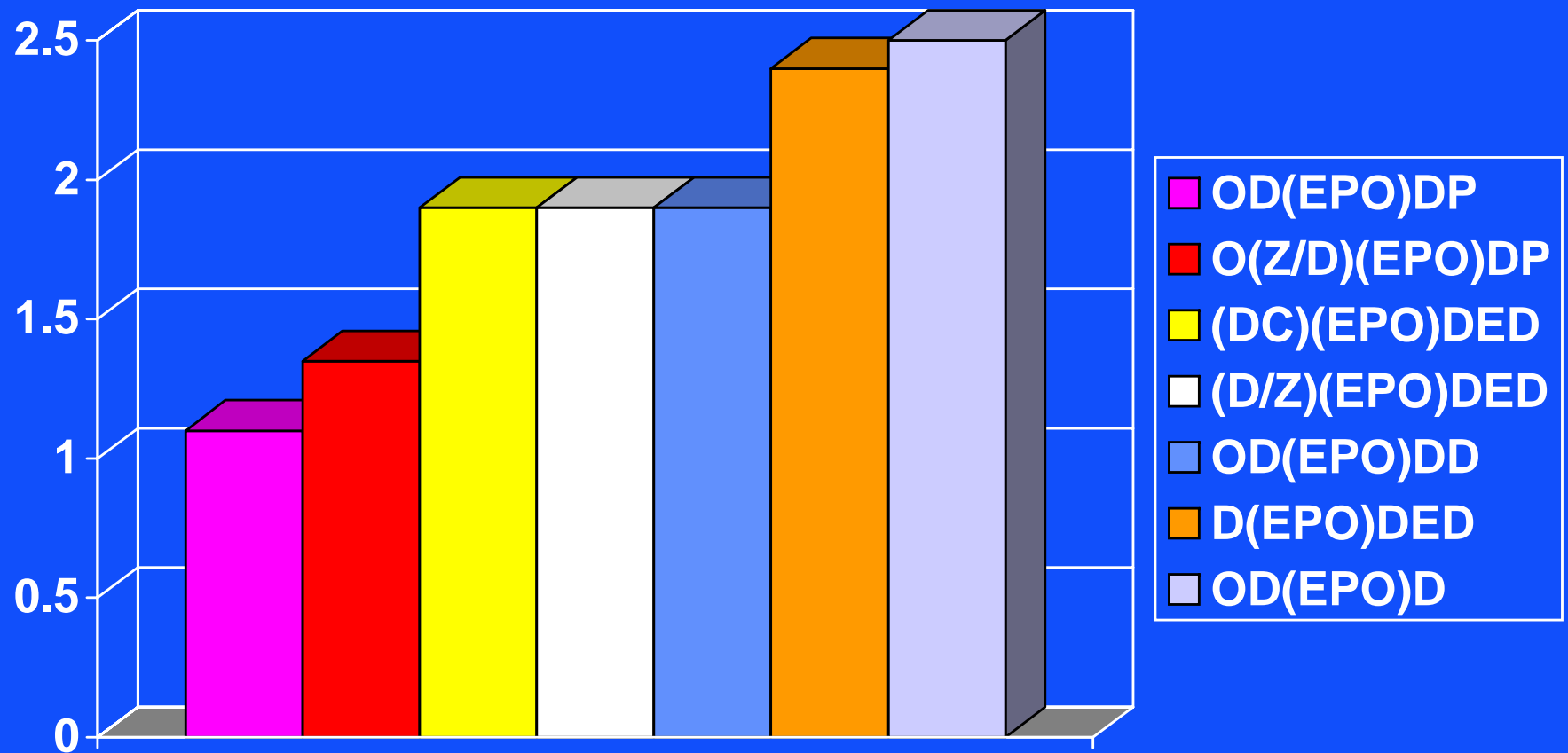


Final Stage of O(Z/D)(EPO)DP



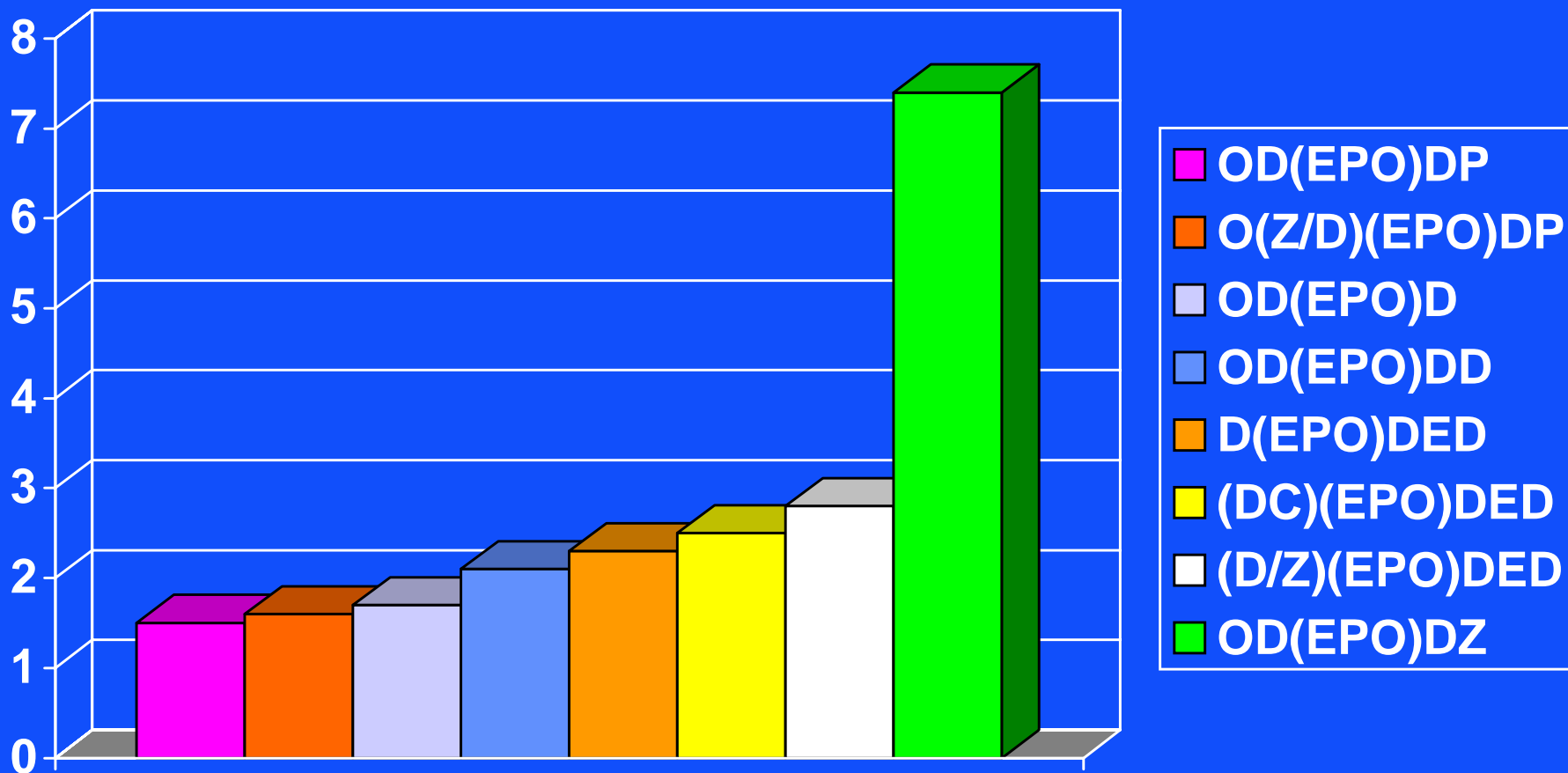
Total ClO₂ Requirement

Total ClO₂ Requirement, %

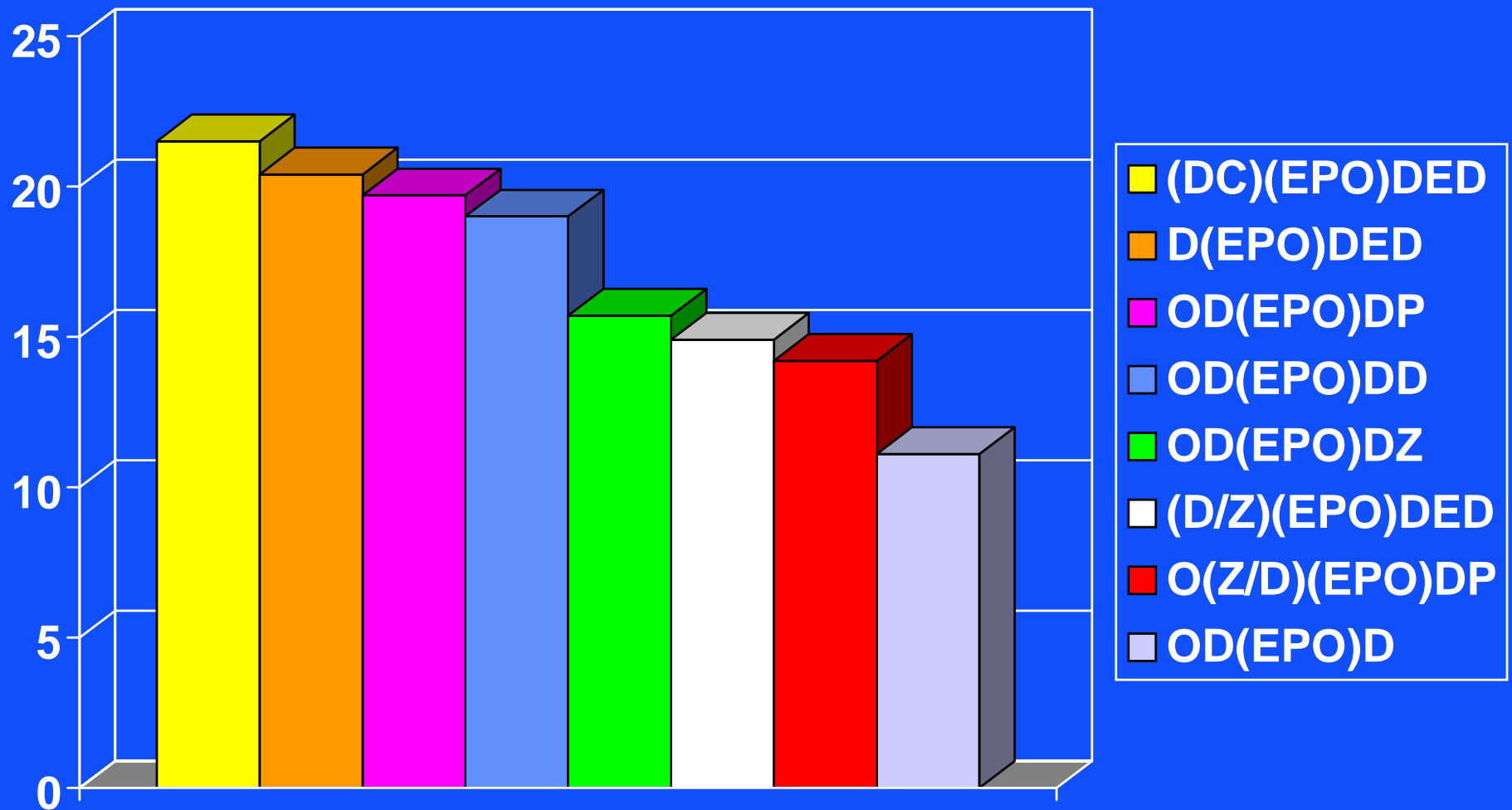


Bleached Pulp Properties

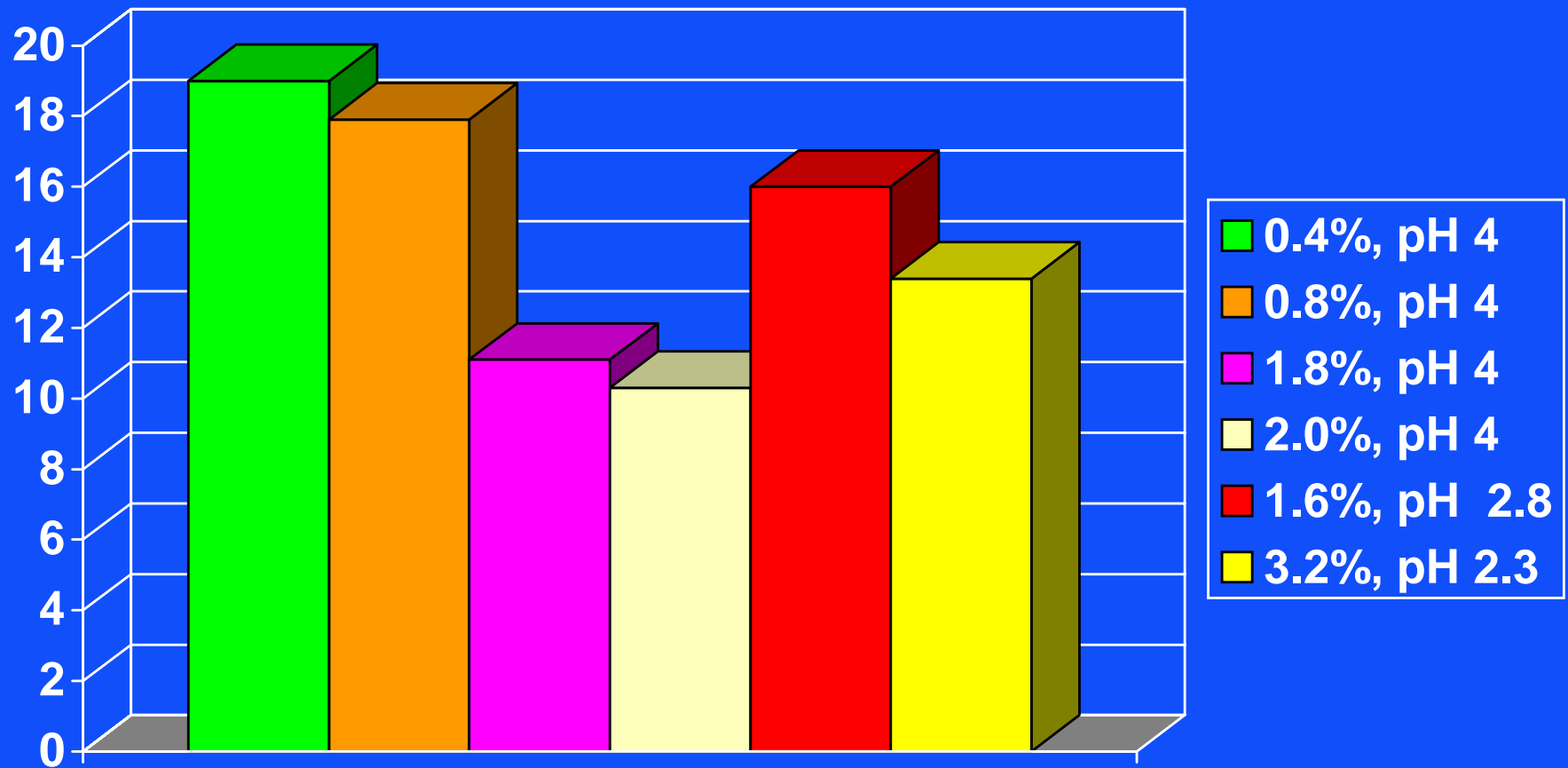
Brightness Loss After 1h @ 105°C



Bleached Pulp Viscosity, mPa·s

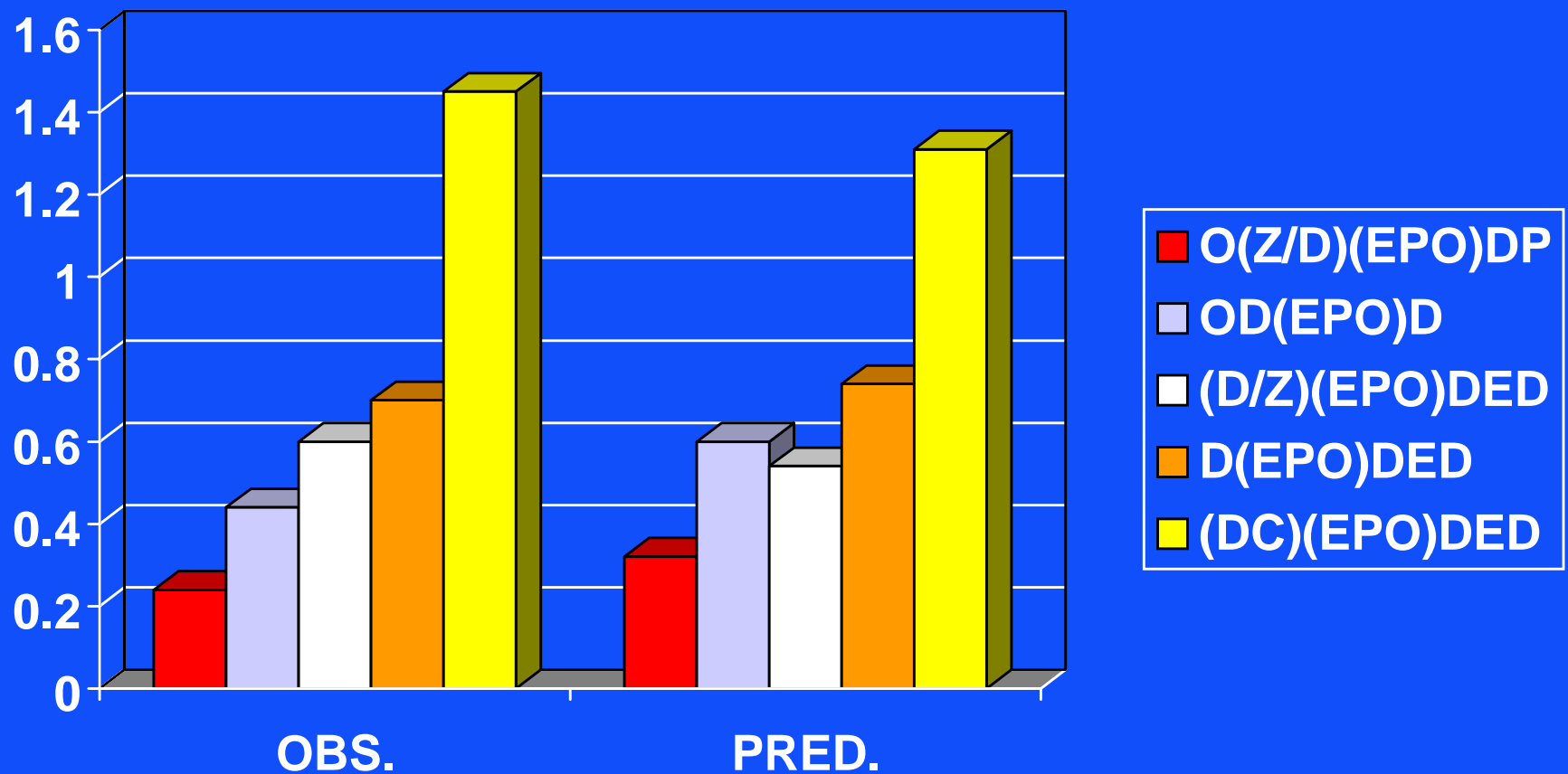


Viscosity vs %ClO₂ and pH in D₁ of OD₀(EPO)D₁

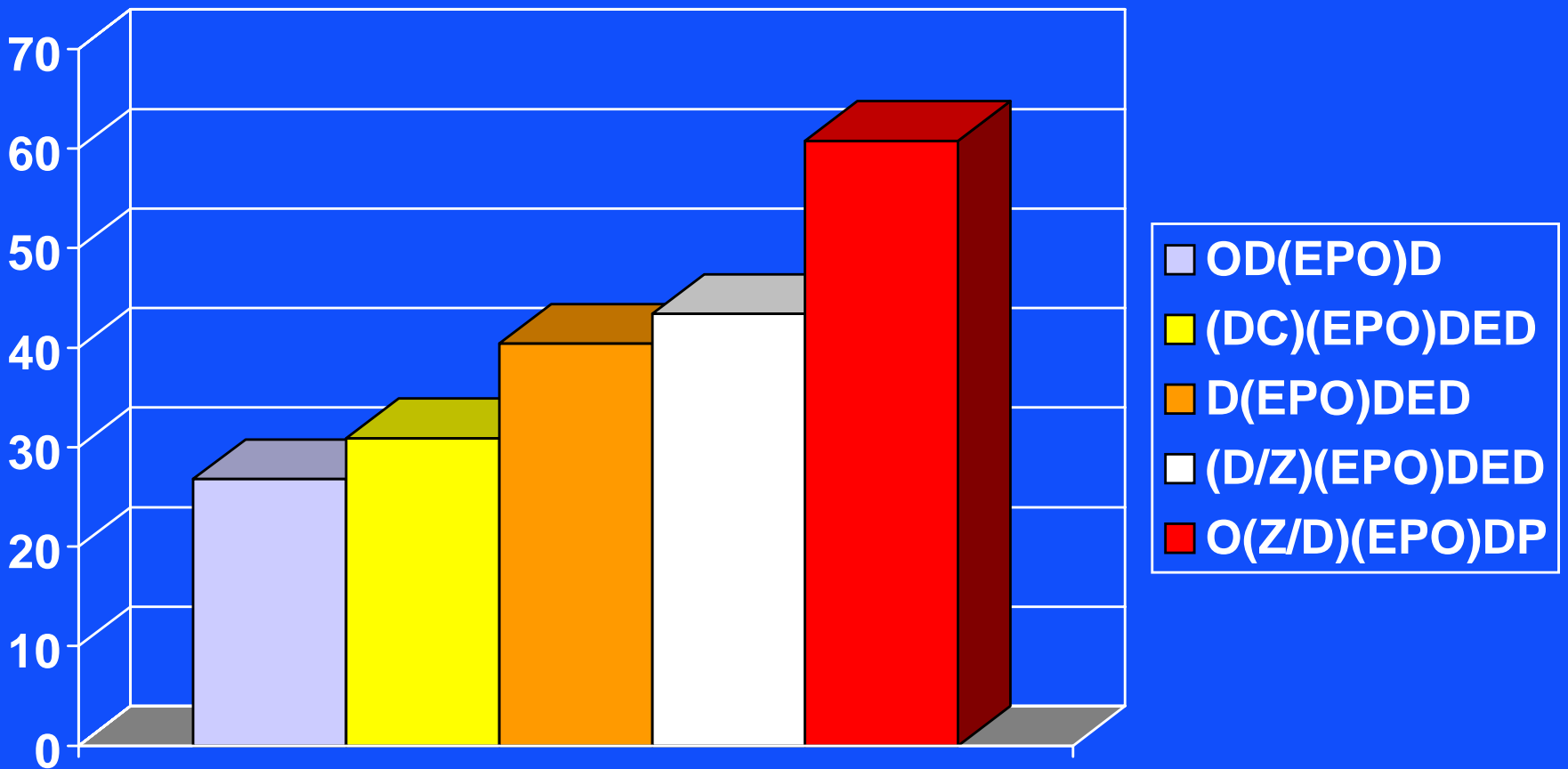


Effluent Properties

Untreated AOX, kg/admt



Untreated COD, kg/admt



Summary and Conclusions

Delignification Stages

- **(DC)(EPO) gives much lower kappa no. than D(EPO)**
- **(D/Z)(EPO) gives the same kappa no. as D(EPO) [1 kg O₃ = 1.7 kg ClO₂]**
- **O(Z/D)(EPO) gives the same kappa no. as OD(EPO) [1 kg O₃ = 1.7 kg ClO₂]**
- **After OD(EPO), the kappa no. is lower when the D stage exit pH is 4 than when it is 3**

Initial Brightening (D_1) Stage

- At a given charge of ClO_2 in D_1 , pulp that had been O_2 delignified was brighter
- Bleaching to a given high brightness in 3 stages needs much less ClO_2 after O_2 delignification
- Critical ClO_2 ratio ~ 0.2 (~ 0.1 after O_2 delig.)
- Moderate filtrate carryover into or beyond the D_0 stage had little or no effect on D_1 brightness
- Substitution of Cl_2 or O_3 for part of the ClO_2 in D_0 has little effect on D_1 bleachability

Final Brightening (89-90 Bright.)

- In the final stage, S, of the OD(EPO)DS sequence, H_2O_2 and ClO_2 were equally effective on a weight basis, O_3 less effective
- Low charges of H_2O_2 were less effective in the O(D/Z)(EPO)DP sequence than in the OD(EPO)DP sequence, but the former sequence was capable of reaching higher brightness at high H_2O_2 charges

Full Sequence

- Total ClO_2 requirement, in ascending order, is
 - ▼ OD(EPO)DP [1.1%]
 - ▼ O(Z/D)(EPO)DP [1.35%]
 - ▼ (DC)(EPO)DED = (D/Z)(EPO)DED = OD(EPO)DD [1.9%]
 - ▼ D(EPO)DED [2.4%]
 - ▼ OD(EPO)D [2.5%]

Bleached Pulp Properties

- Brightness reversion was similar for all sequences except better for sequences ending in P and poorer for the one ending in Z
- Viscosity appears to be adversely affected by exclusion of carryover and inclusion of an ozone stage
- The OD(EPO)D sequence has the potential to give low viscosity because of the high ClO_2 charge needed in the final stage when KF 0.2

Effluent Properties

- **AOX generation levels agreed with predictions of a pre-existing empirical model, ranging from 0.24 to 0.74 kg/admt for the ECF sequences studied**
- **COD values ranged from 27 kg/admt for OD(EPO)D to 61 kg/admt for O(Z/D)(EPO)DP**

Chemical Costs

- All 5-stage sequences had similar chemical cost
- O_2 - delignified pulp can be bleached in 3 stages at the same cost as a 5-stage sequence on brownstock
- Addition of another D stage to OD(EPO)D reduces chemical costs by 20%; addition of a P stage gives similar savings but 1 point lower brightness
- Partial replacement of ClO_2 with O_3 in D_0 increased chemical costs at high brightness

Acknowledgments

- Air Products and Chemicals
- FMC Corporation
- Georgia Traditional Industry Program in Pulp and Paper
- Member Companies of the Institute of Paper Science and Technology