Recent Commercialization Developments of PAMAM and PAMAMOS Dendrimers by Dendritech, Inc.

Sixth International Dendrimer Symposium

Stockholm, Sweden

June, 2009

S. Emery Scheibert
Dendritech, Inc.
3110 Schuette Dr.
Midland, MI 48642

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MISSION STATEMENT:

We build value utilizing dendritic polymer technology to create cost-effective solutions for our customers.

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Dendritech supplies more than 40 dendrimer products worldwide in quantities ranging from 100 milligrams up to multiple kilograms.

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Dendritech, established in 1992 in Midland, Michigan has been supplying dendrimer products worldwide for over 15 years.

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Dendritech History

-The dendrimer patent portfolio was licensed exclusively from the Dow Chemical Company in 1992. Signed exclusive license agreement with Baxter Diagnostics (Dade-Behring/Siemens) for use in in-vitro diagnostics with license fee and product sales royalty.

-Corporate offices and manufacturing facility completed in 1993. Lab process commissioned in 1994. First commercial sale of product through Sigma-Ald

-Manufacturing pilot plant commissioned in 1995.

-First customer launches commercial product using PAMAM dendrimers in 1998

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Dendritech has been distributing over 40 different dendrimer products through Sigma-Aldrich since 1994.

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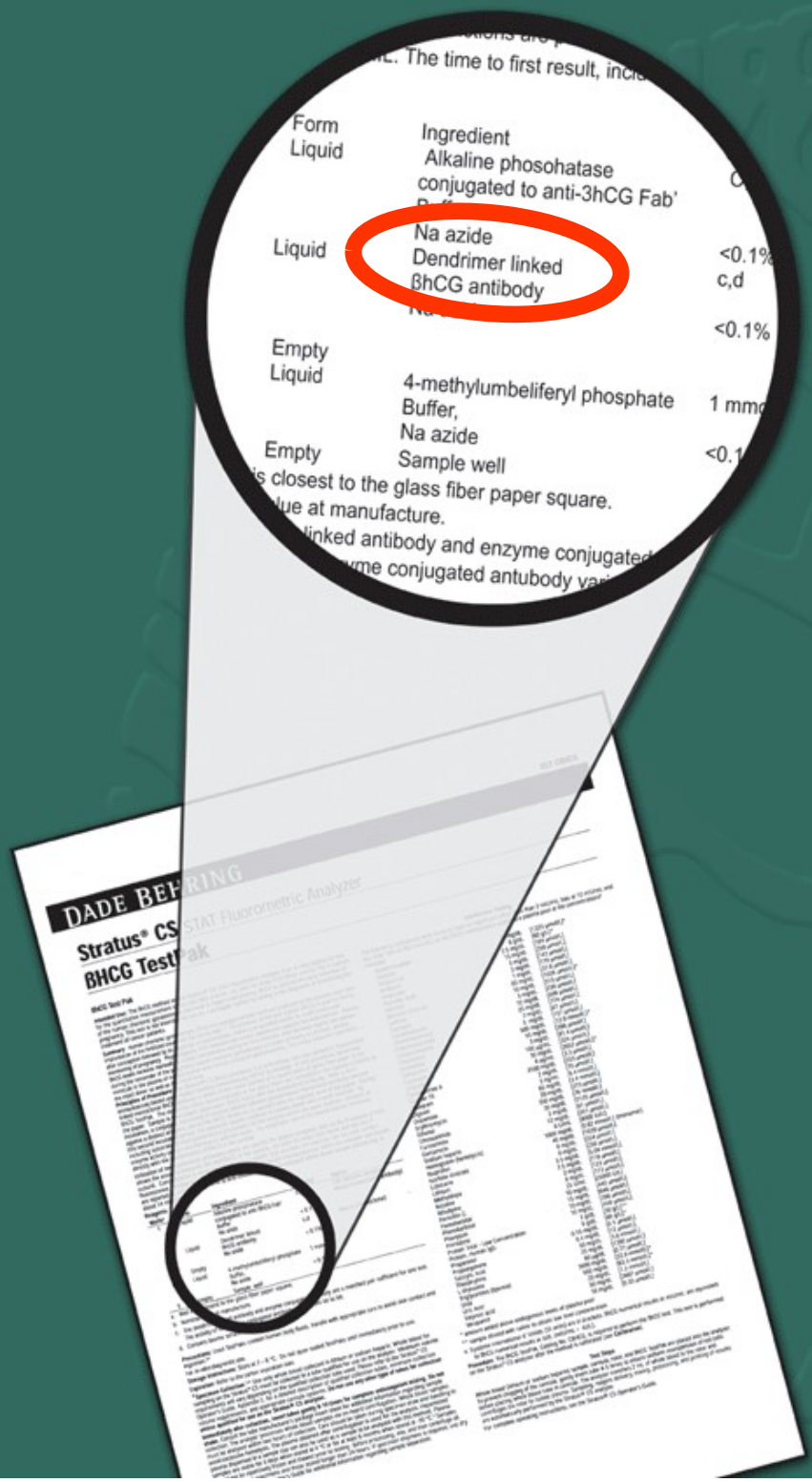

Dendritech is the exclusive supplier of dendrimers for Siemens (Dade-Behring) Stratus CS heart attack assay.

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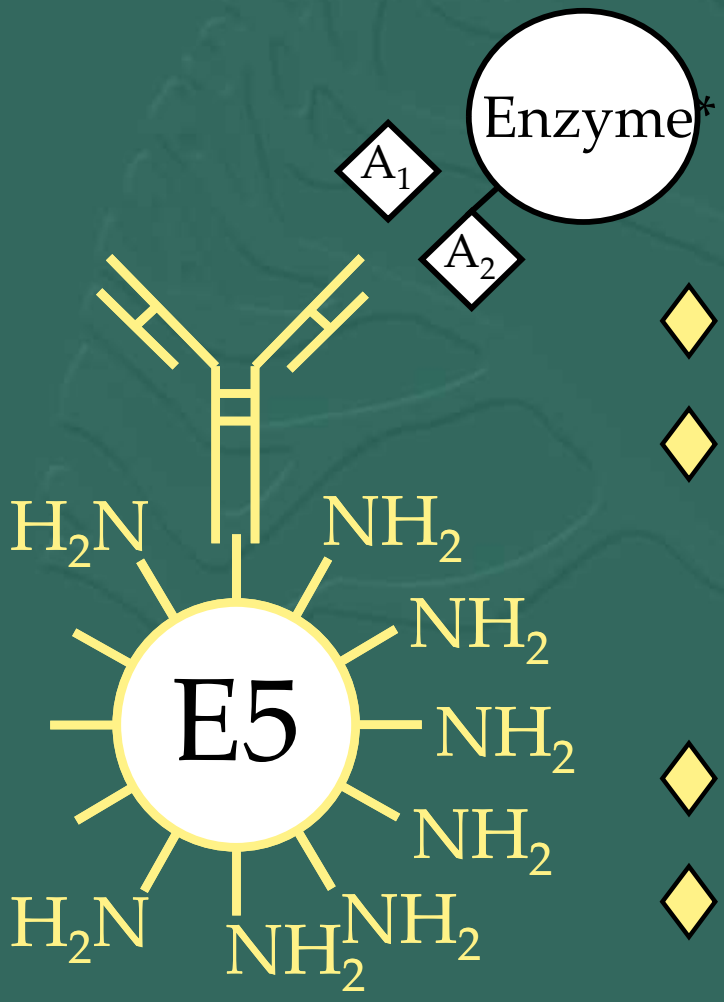
Siemens
(Dade-Behring, Inc.)

Stratus® CKMB Immunoasssay

Clinical Chem. 40, 1845 (1994)



- Faster assay due to solution kinetics
- Good partitioning due to high affinity of the dendrimer/antibody conjugate for the fiberglass substrate
- Stabilize antibody
- Competitive analysis for antigens A_1 and A_2

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Current Dendrimer Commercialization Projects:

1.Environmentally Benign Antifouling Coatings for Marine Applications.

2.Ultra-Low k Interlayer Dielectrics.

3.Nano-structured Biocidal Coatings Targeting Spore-Forming Bacteria.

4.Hard, Scratch-Resistant Cross-liked Polymer Coatings for Optical Lenses.

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Environmentally Benign Antifouling Coatings for Marine Applications

Current products leach biocidal agents into the water and pose an environmental impact that is subject to regulation. Tri-n-butyl tin (TBT) is banned in the U.S. and copper based paints are banned in the Netherlands for recreational vessels.

The final product must be priced similar to conventional antifouling paints but may last more than one season because the biocide is retained longer and the coating remains.

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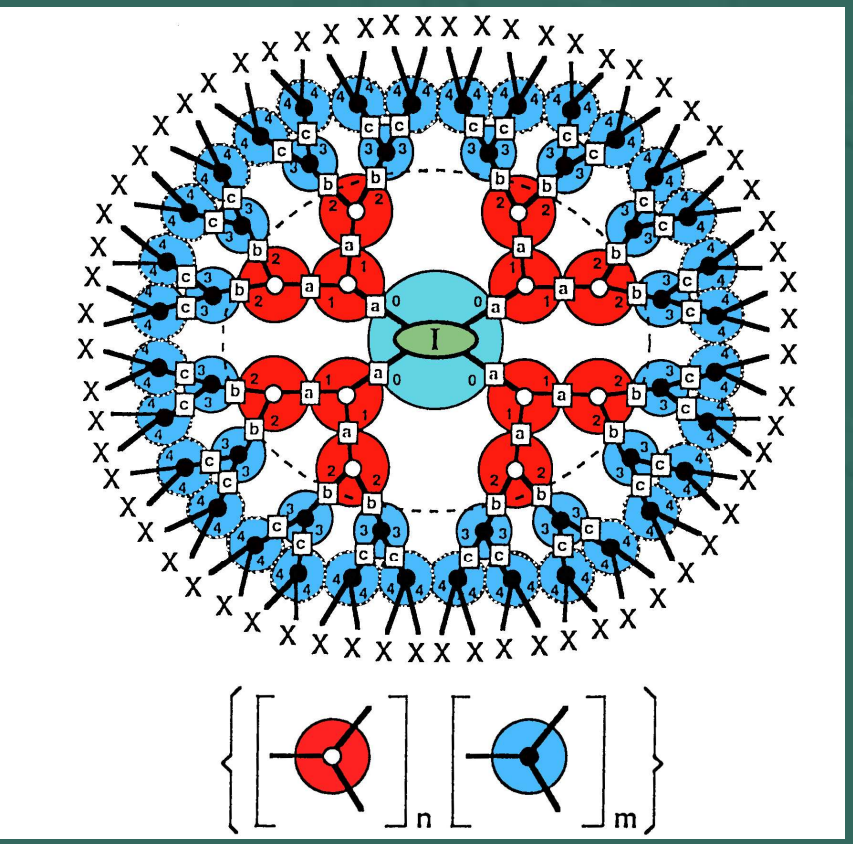
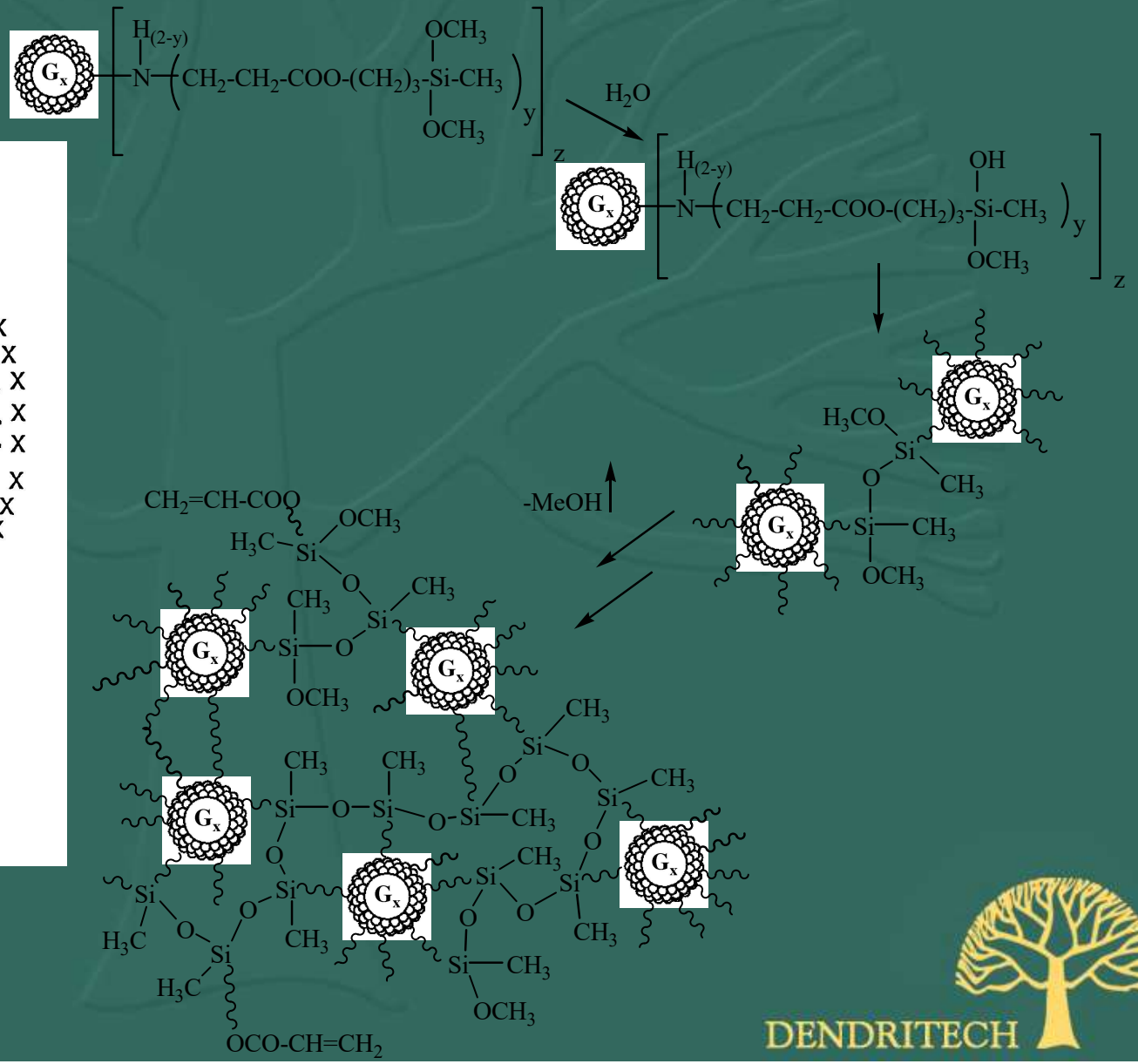
Environmentally Benign Antifouling Coatings for Marine Applications

PAMAMOS DENDRIMER NETWORKS





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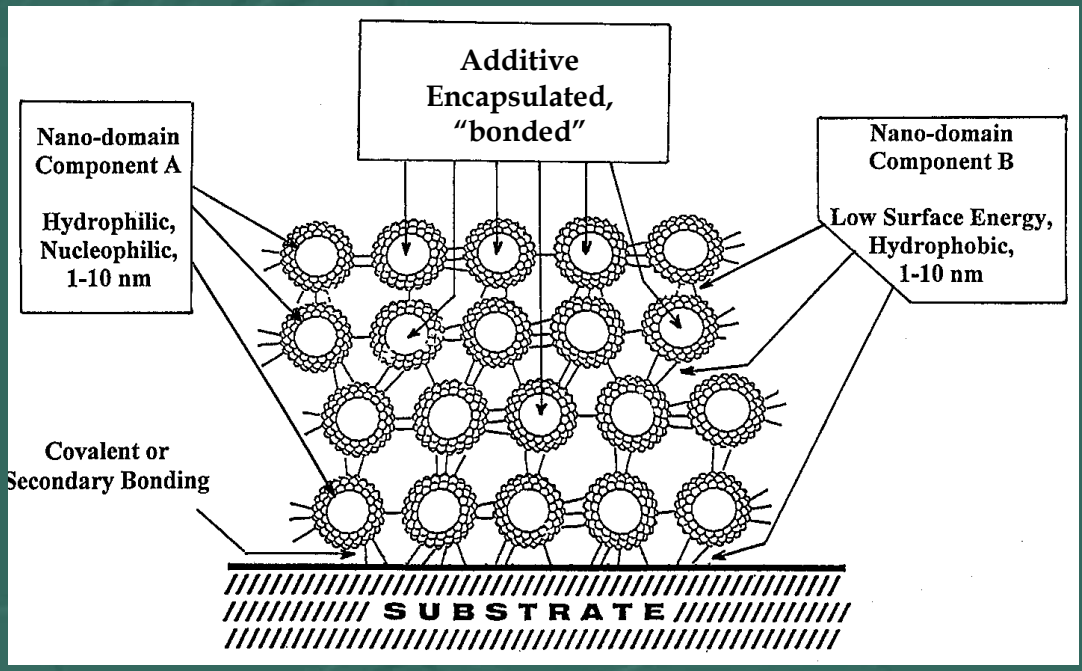
Environmentally Benign Antifouling Coatings for Marine Applications



The antifouling agent is embedded in dendritic molecules and trapped in a nano-sized cross linked polymer matrix.

Biocidal activity is retained because of its close proximity to the surface.

The antifouling compound does not leach into the surrounding water because it is bound in the matrix.

The coating has a low surface energy comparable to silicone based coatings.

Can be formulated and applied similar to current antifouling paints.

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Environmentally Benign Antifouling Coatings for Marine Applications

Florida Test – 3 Month Exposure Feb/07

A – Competitor Control, soft antifouling

B – Competitor Control, hard antifouling

L – Control, Polyester gelcoat with 3 coats of wax

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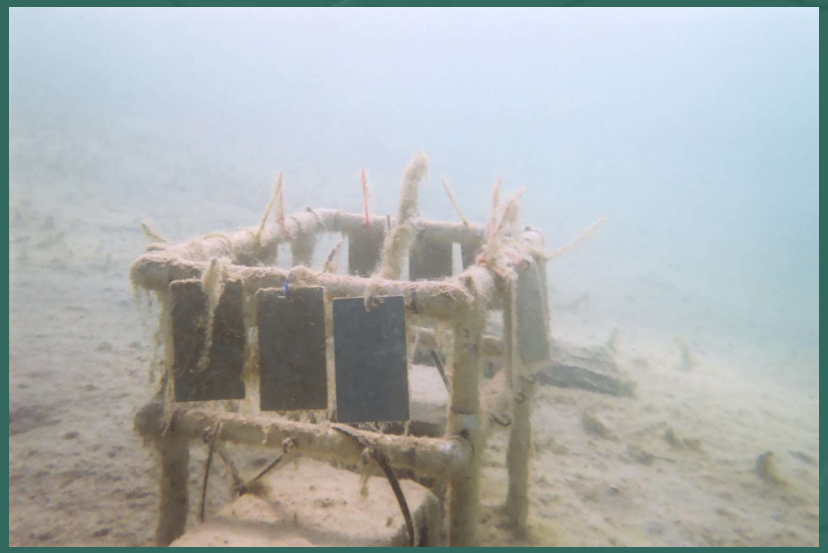
Environmentally Benign Antifouling Coatings for Marine Applications

Leaching Data

Sample	Water Type	Cu2+ (in film), wt. %	Cu2+ in water (after 1 month), ppm	Cu2+ in water (after 3 months), ppm	Cu2+ in water (after 1 year), ppm
3	Lake water 1	0.96	<0.01	0.06	<0.05
4	Lake water 2	0.32	<0.01	<0.02	<0.05
5	Lake water 3	0.32	<0.01	<0.01	<0.01

a.About 1 inch circular films exposed to about 25 g of water.
b.Copper analysis of water samples performed by an independent analytical laboratory. Measuring sensitivity: 0.01 ppm.
c.Samples of lake water and two de-ionized buffer solutions were used as controls. All of them showed no difference from sample 4. Lake water was lakes Wixom and Sanford, Michigan.



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Environmentally Benign Antifouling Coatings for Marine Applications

The active dendritic polymer component of the coating is 30% of total value.

Based on 25% penetration of US pleasure craft market ($43 million) the total revenue is $3.2 million.

We will supply active dendritic polymer component to paint formulators with existing distribution channels.

Current commercialization partner is Gougeon Bros.

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Ultra-Low k Interlayer Dielectrics

ITRS Roadmap

Year of Production	2003	2004	2005	2006	2007	2008	2009	2010	2012	2013	2015	2016	2018
Technology Node		hp90			hp65			hp45		hp32		hp22	
MPU/ASIC ½ Pitch (nm)	120	107	95	85	76	67	60	54	42	38	30	27	21
Interlevel metal insulator (minimum expected) – bulk dielectric constant (k)	<3.0	<2.7	<2.7	<2.7	<2.4	<2.4	<2.4	<2.1	<2.1	<1.9	<1.9	<1.7	<1.7
Interlevel metal insulator (minimum expected) – effective dielectric constant (k)	3.3 – 3.6	3.1–3.6	3.1–3.6	3.1–3.6	2.7–3.0	2.7–3.0	2.7–3.0	2.3-2.6	2.3-2.6	2.0-2.4	2.0-2.4	<2.0	<2.0

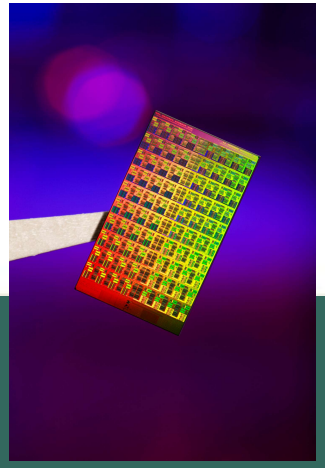
Currently introduced in volume production (behind schedule)

k_{eff} = 3.1 could be achieved by integration of dense 2.7 - type material with SiC -based assist layer at k=4.5

k_{eff} = 2.7 cannot be achieved by:
- integration of a dense 2.7 - type material with SiC-based assist layers at k=4.5
- or a porous 2.4 material if sidewall etch damage occurs even without etch-stop
- Introduction of lower k hardmask and etch-stop layers required to achieve k_{eff}

k_{eff} = 2.5 will require:
- Bulk low k of <2.2 with minimal sidewall damage
- low k hardmask and etch-stop layers (k<2.8)
- Elimination of trench etch-stop desirable
- Introduction of metal cap and low k diffusion barrier/vias etch-stop

Significant innovation required in the areas of:
- Damage-free etch, ash and clean
- Damage-free integration
- Low k materials



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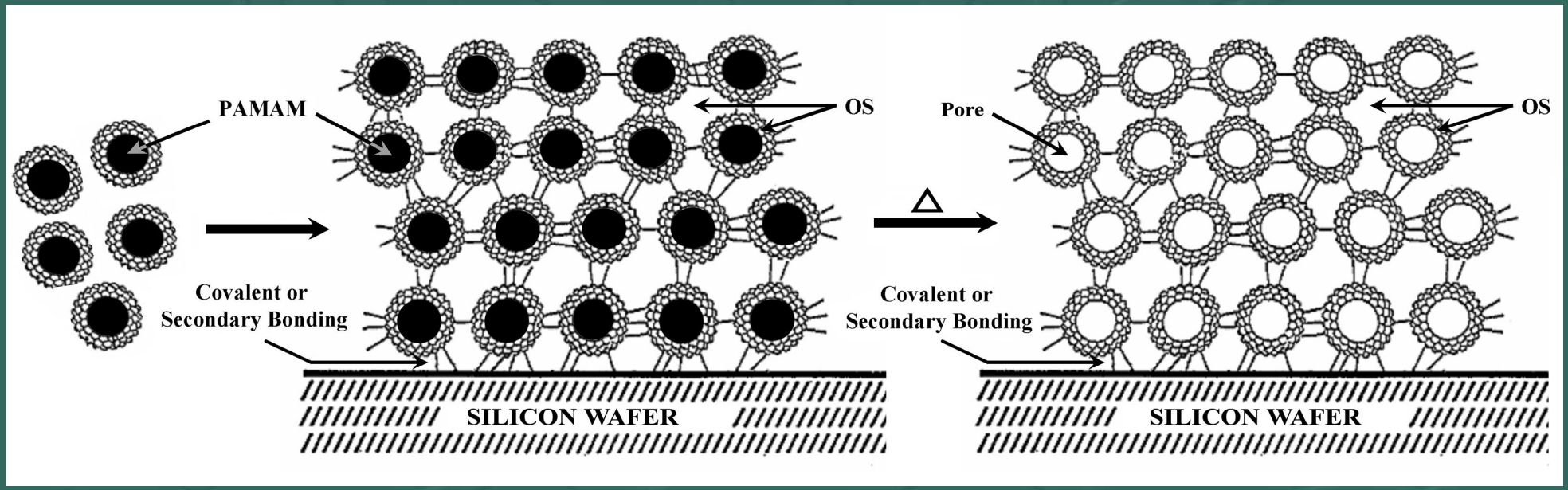
Ultra-Low k Interlayer Dielectrics



FORMATION OF NANOPOROUS ILDs FROM PAMAMOS DENDRIMER NETWORKS

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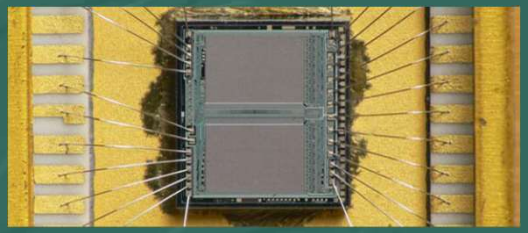
Ultra-Low k Interlayer Dielectrics

Preliminary Results

	Pre-Cure	Pre-Cure	Cure	Cure	Thickness			Dielectric		
Wafer #	Temp (C)	Time (min)	Temp (C)	Time (min)	(A)	St. Dev.	RI	St. Dev.	Constant	St. Dev.
1	150	10	225	10	2631	95	1.187	0.033	2.09	0.15
2	175	10	225	10	3652	434	1.251	0.083	2.42	0.28
3	150	10	225	10	2118	77	1.26	0.016	1.7	0.08
4	175	10	225	10	2440	261	1.249	0.084	1.79	0.04
5	150	10	225	10	2234	41	1.394	0.009	1.86	0.1
6	175	10	225	10	2420	191	1.349	0.052	2.06	0.06
7	150	10	225	10	2781	124	1.221	0.072	2.18	0.18
8	175	10	225	10	2159	101	1.295	0.04	2.46	0.42
9	150	10	225	10	3894	246	1.189	0.105	2.63	0.04
10	175	10	225	10	2912	99	1.288	0.043	1.96	0.02

Ultra-Low k Interlayer Dielectrics

Economics and Commercialization



Product: G4 PAMAMOS Technical Grade.
Cost: $ 2,000/ Kg
Typical yield: 35 m2/kg
- -1m2 of 25 µm coating $57 or less;
- - to coat 100 mm Si wafer with 2µm film 3.6 ¢/layer

DOW®

Electronic Materials

Rohm & Haas - Shipley

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Nano-structured Biocidal Coatings Targeting Spore-Forming Bacteria

- Approx 10% of hospital patients in US will acquire Hospital Acquired (nosocomial) infections in the hospital
- In 1995 there were 88,000 deaths in the US from these infections.
- In 2004 400,000-500,000 cases in the US (CDC estimate)

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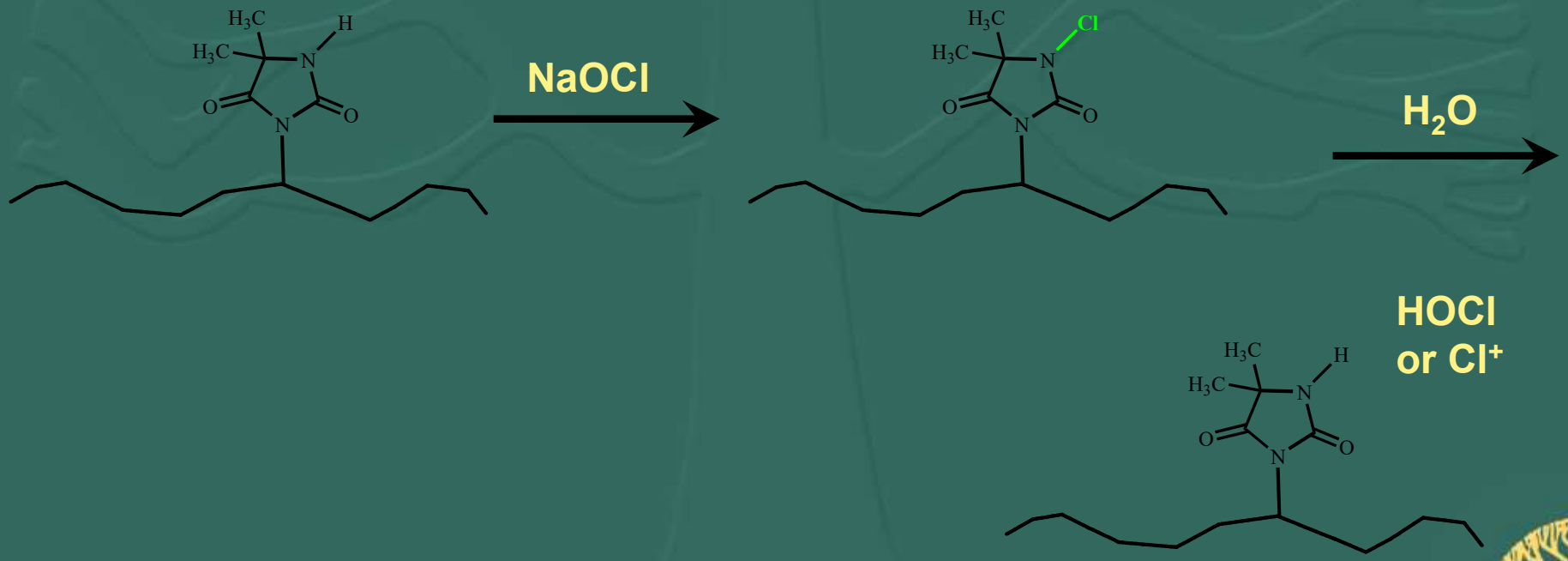
Nano-structured Biocidal Coatings Targeting Spore-Forming Bacteria

N-halamine grafted to polymer

- A convenient source of biocidal chlorine with all of the advantages typically associated with a curable polymer coating
- Treatment with chlorine source converts N-H bonds to N-Cl
  - Cl_2 gas
  - NaOCl (commercial bleach)
- After being consumed, N-Cl bonds can be regenerated over and over again through treatment with bleach



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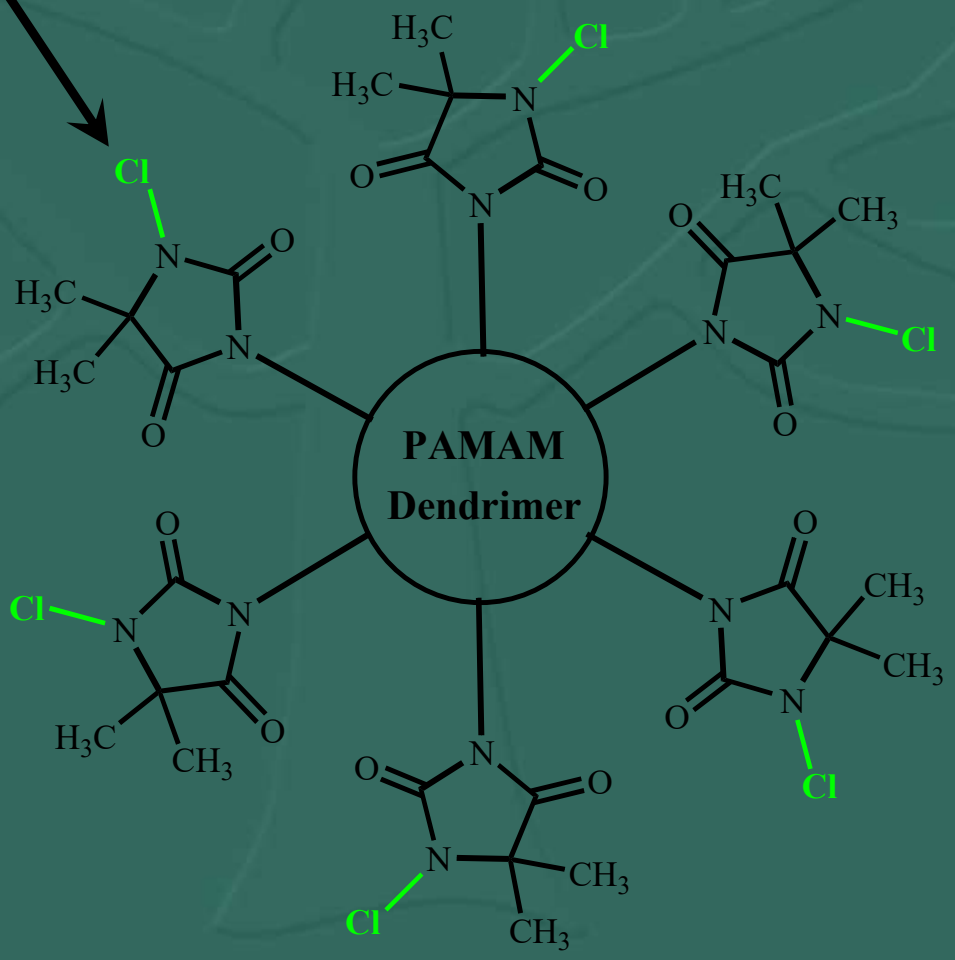
Nano-structured Biocidal Coatings Targeting Spore-Forming Bacteria

N-Chlorohydantoin PAMAM Dendrimer

High surface density of antimicrobial, chlorine-releasing functional groups located primarily at the periphery



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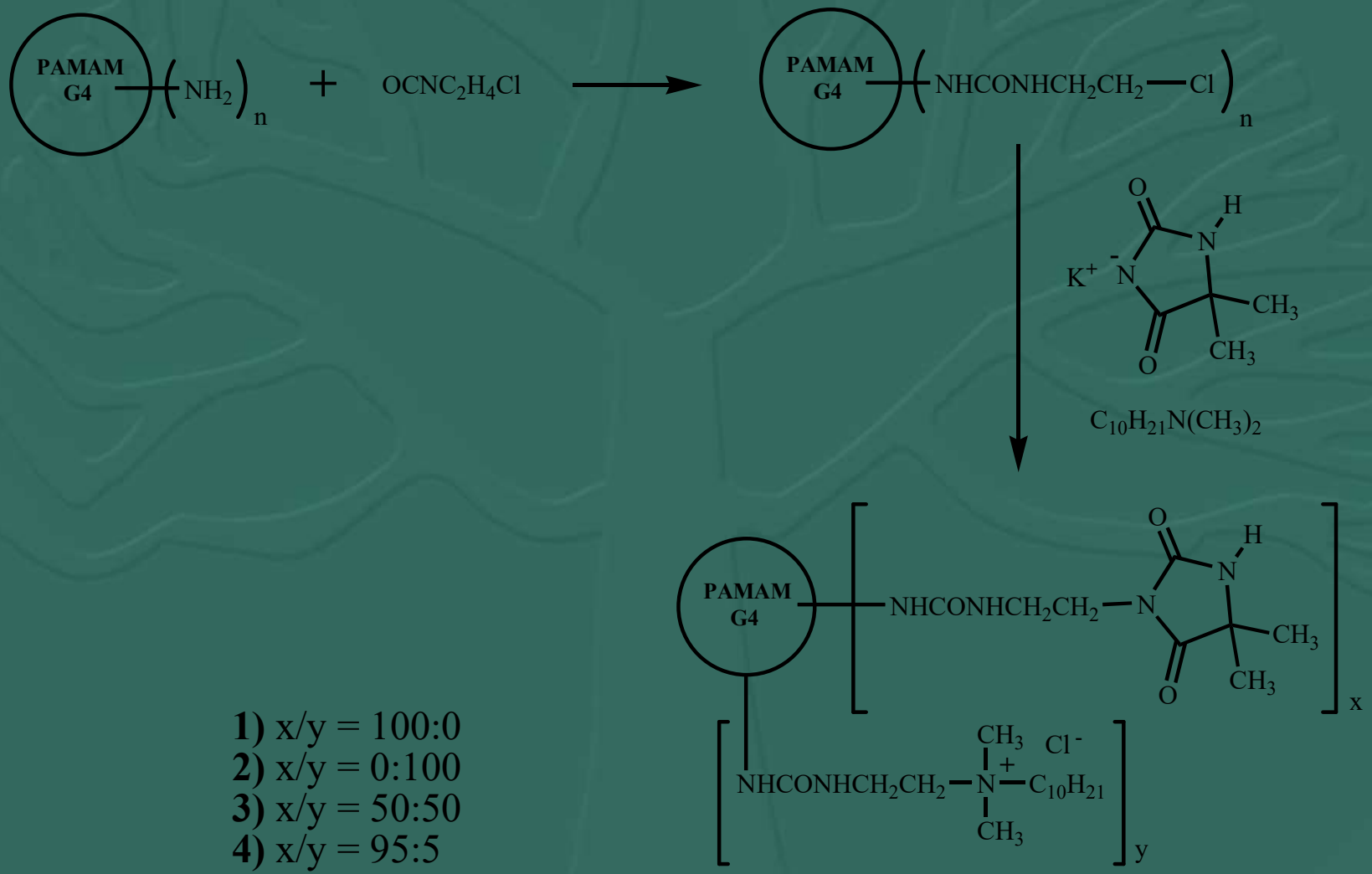
Nano-structured Biocidal Coatings Targeting Spore-Forming Bacteria

Synthesis of Hydantoin/QAC Mixed-Surface PAMAM



1) x/y = 100:0
2) x/y = 0:100
3) x/y = 50:50
4) x/y = 95:5

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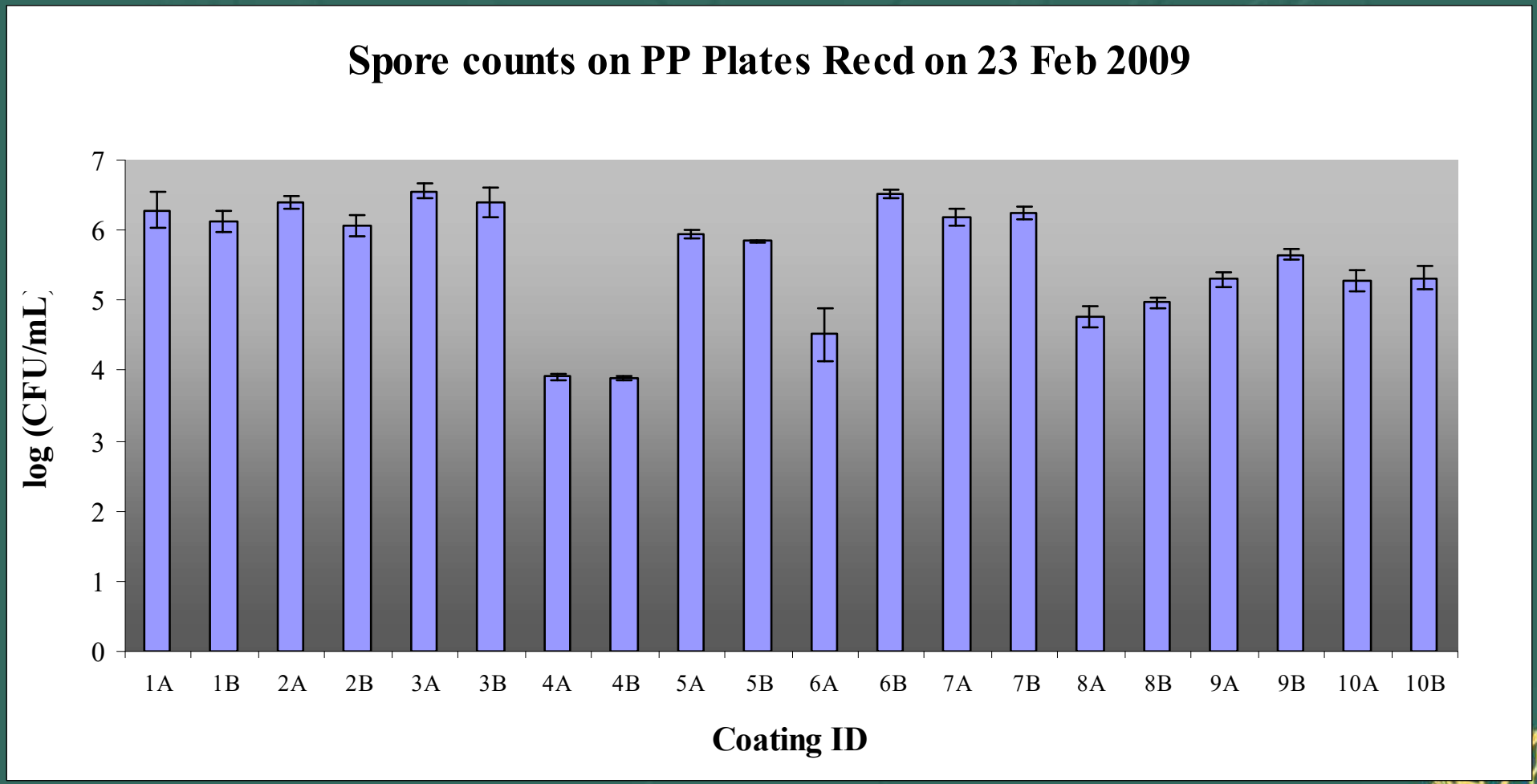
Nano-structured Biocidal Coatings Targeting Spore-Forming Bacteria

Exposure to Sterne Strain *Bacillus anthracis* Spores



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Hard, Scratch-Resistant Cross-liked Polymer Coatings for Optical Lenses.

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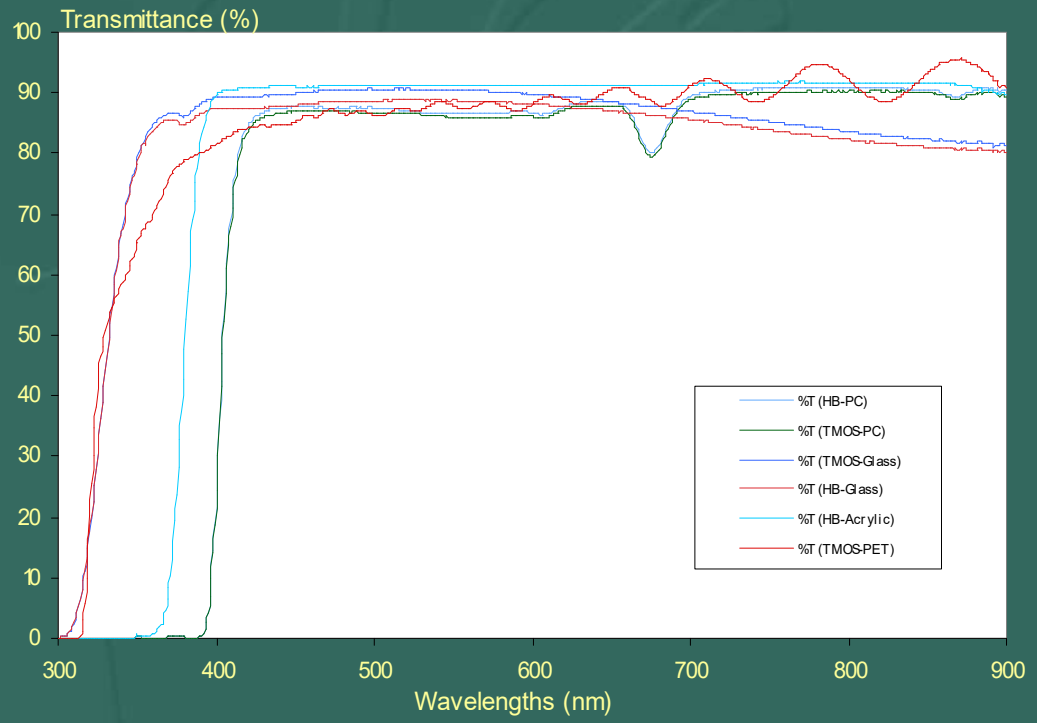
Hard, Scratch-Resistant Cross-liked Polymer Coatings for Optical Lenses.

DENDRITIC POLYMERS-BASED TRANSPARENT HARD COATINGS

Sample	Substrate	Pencil Hardness	Transparency at 550 nm, %
PAMAMOS – TMOS	Glass	7H	90.2
HB – TMOS	Glass	7H	88.8
PAMAMOS – TMOS	PC	5H	85.5
HB – TMOS	PC	5H	86.6
HB – TMOS	Acrylic	5H	91.2
HB – TMOS	PET	4H	88.6



*Pencil hardness (ASTM D3363-05)

•TMOS = G3; HB = DETA/HMDI; RT 2h + 120°C 2 h (G3 up to 16 h); paintbrush from 25% MeOH solutions

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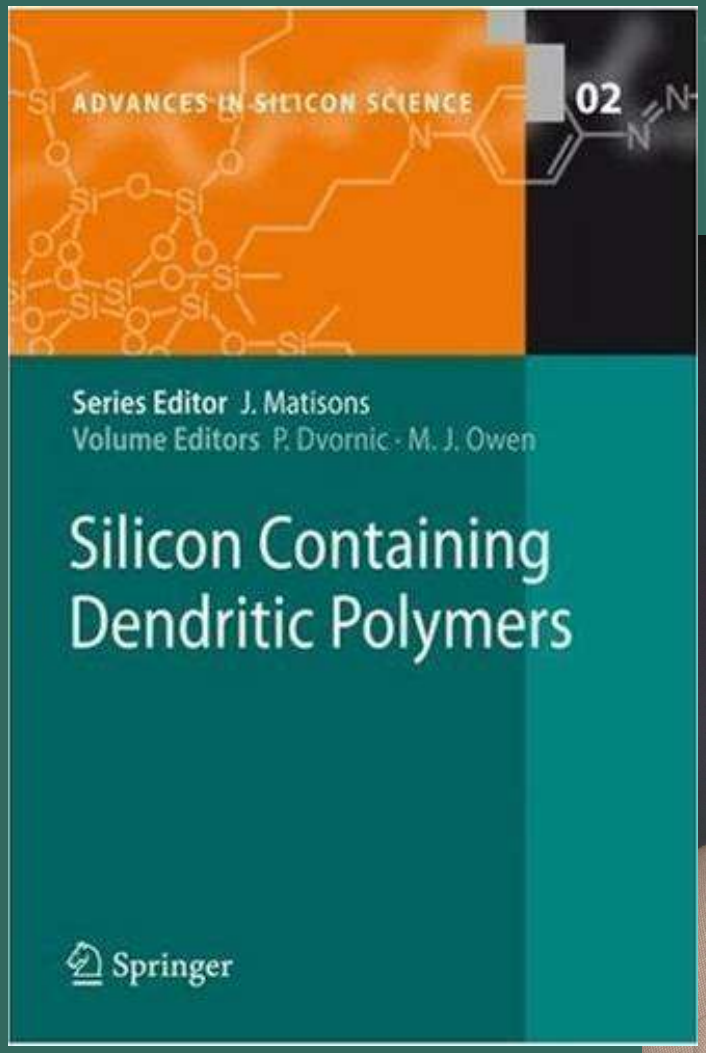

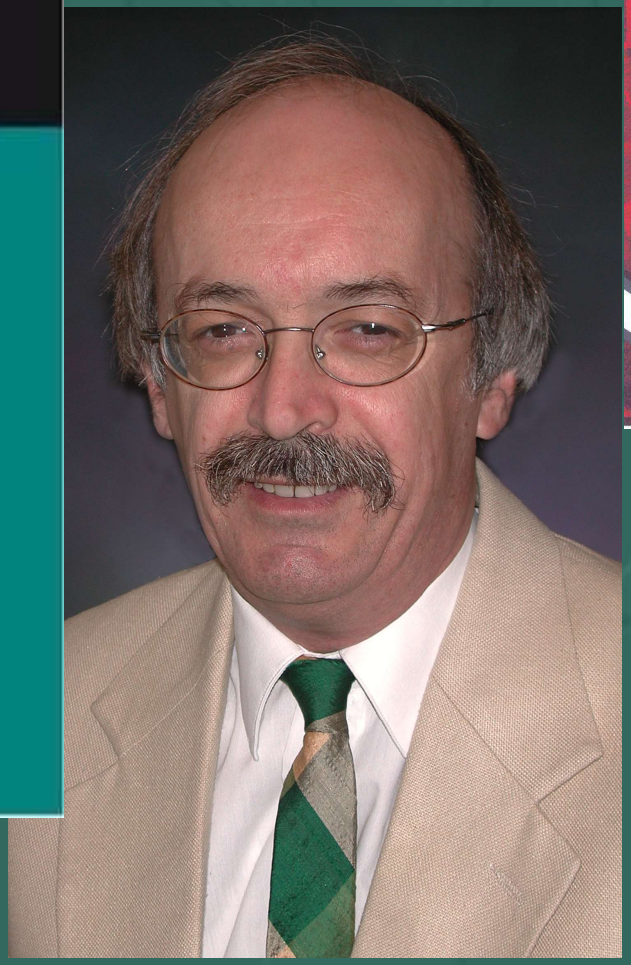

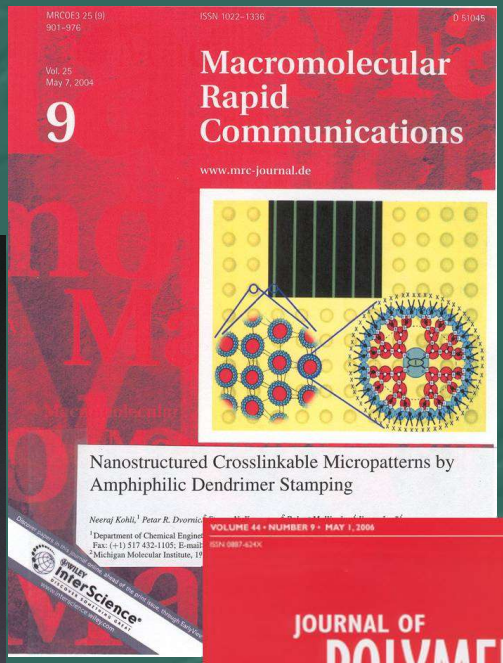

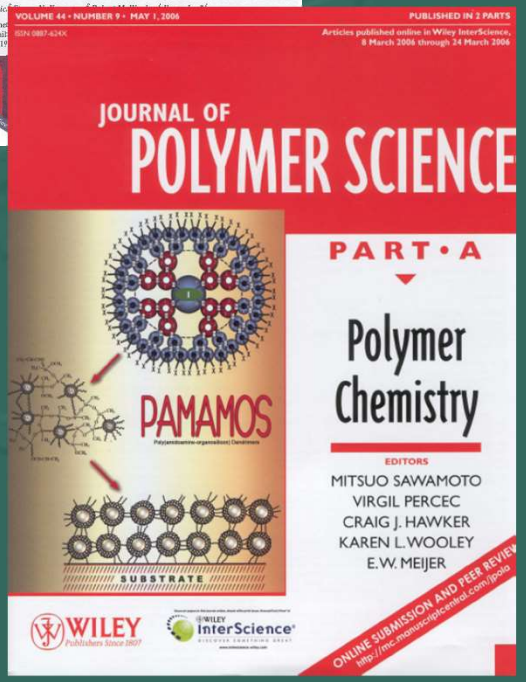

The "Silicon-Containing Dendritic Polymers" lecture will be presented on Monday, August 17, 2009 at the Silicones and Silicone Modified Materials symposium within the 238th ACS National Meeting in Washington DC, August 16-20.

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