Biological Protective Performance of Medical Textiles

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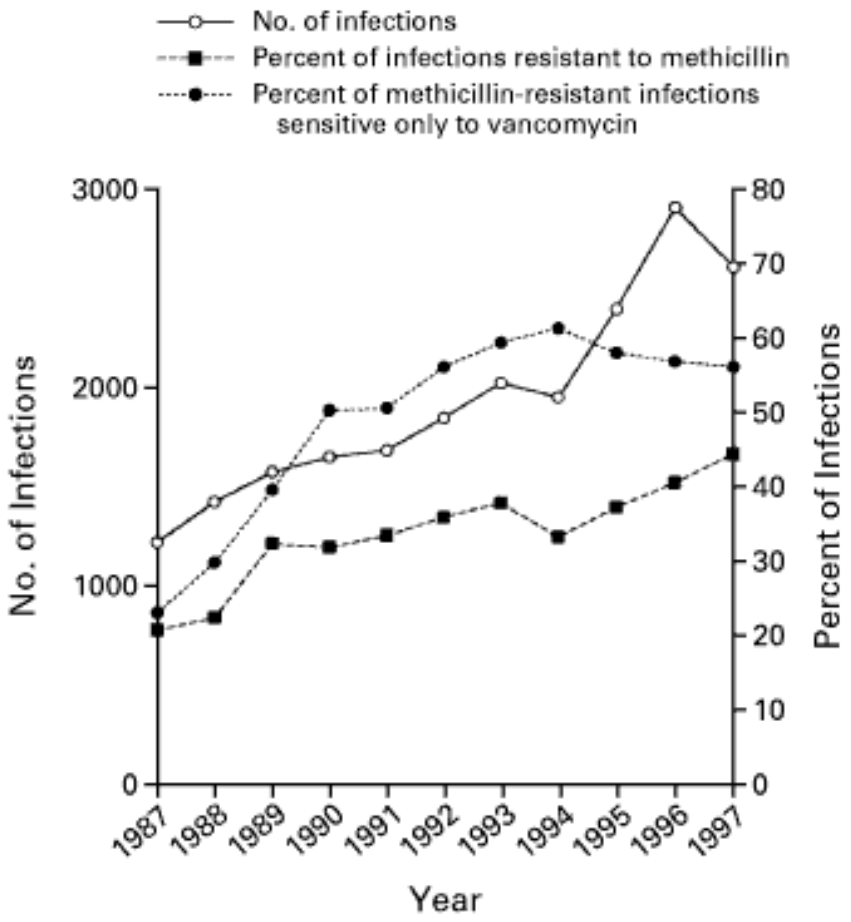
Challenges in Hospitals

- **Nososcomial infection rate has been growing rapidly in recent years and has become a serious concern for healthcare community**
- **Surface contact transmission is a major factor contributing to the disease spreading**
- **Survival of many microorganisms on textile materials have been proven, which may contribute to the contact transmission**
- **Antimicrobial textiles can serve as a good means to reduce microorganisms on their faces and consequently reduce nosocomial infection in hospitals**

S. aureus and MRSA Infections*



***S. Aureus* infections in Intensive Care Units in the National Nosocomial Surveillance System, 1987-1997**

***Lowy, FD, *The New England Journal of Medicine*, August 520-532, 1998**

Hospital Related Infections of Diseases (Hospitals-Nosocomial Effect)

- **One in 20 hospitalized Americans**
- **1.8 million people — develop an infection**
- **88,000 of them dying**
- **97% of the infections caused by medical materials**

SARS Infections and Lessons*

- **SARS can survive on hard surface for one or more days**
- **Spread of SARS among patients and health care workers, particularly for those who did not have direct contact with SARS patient**
- **Some healthcare workers were infected even with full protective gear**

*** Wenzel and Edmond, Annals of Internal Medicine, V139, 592, 2003**

Clothing as A Second Skin to Human Body

- Development and evaluation of personal protective equipment against infectious diseases, biological agents, and toxic chemicals
- Textiles and materials science for preventing the transmission of infectious diseases and harmful agents, and improving food safety, human health and well-being
- Physical, sociological, economic, environmental, and human health implications of protective textiles and materials

New and Ever Increasing Health Threats

- Diseases, epidemics, insects, and environmental challenges with the world's increasing population, along with the impact of human activities on the environment
- Finding sustainable material solutions for personal protection and human health against these threats requires the understanding of clothing-human interactions and the involvement of multi-disciplinary experts

Sustainable Materials for Human and Environmental Health

- Clothing materials to protect against emerging infectious diseases, insects, toxins and chemical agents
- Polymeric materials to clean air, ground-water contamination and trace-metal poisoning
- Sustainable materials to restore human health and protect environment

Our Goals

- Study of the prevention of diseases and protection of human and environmental health by developing functional polymeric and textile materials
- Increase and promote disease prevention and human protection research programs by using clothing, including material research on the development of novel functional textiles and social, economical, and environmental studies of the functional materials.
- Establish collaborative partnerships with scientists and programs on the Davis campus and within the UC system to address issues and coordinate efforts to prevent disease and protect human health by using polymeric and textile materials
- Integrate and globalize research and education on disease prevention and human protection in the areas of water-borne, food-borne, air-borne, and vector diseases. The existing close international connections and collaborations serve to further expand this network to address global concerns on disease prevention and human protection.
- Provide practical training for researchers and the skilled workforce in effective materials and techniques required for disease prevention and human protection and laboratory research in the US and in endemic countries; address social, economical, and environmental issues emerging from the use of textiles.

Current Technologies

- Barrier materials-block penetration of liquid
  - Reusable and disposable surgical gowns and drapes
  - Reusable and disposable surgical face masks
  - Disposable gloves
  - Reusable linens and garments
- Prevent penetration of liquids but still can transmit pathogens through surface contacts

Current Standards for Surgical Attires

ANSI/AAMI Classifications for Fluid Resistant Performance

Level	Test	Result	AQL Requirement
1	AATCC 42:2000	≤ 4.5 g	4%
2	AATCC 42:2000 AATCC 127:1998	≤ 1.0 g ≥ 20 cm	4% 4%
3	AATCC 42:2000 AATCC 127:1998	≤ 1.0 g ≥ 50 cm	4% 4%
4	ASTM F 1671:2003* ASTM F 1670:2003**	Pass Pass	4% 4%

AATCC 42: 2000 – Impact Penetration Test
AATCC 127: 1198 - Hydrostatic Head Test
ASTM F 1671:2003 - Resistance to Penetration to a Simulated Virus
ASTM F 1670:2003 -Resistance to Penetrated by Simulated Blood

Test Methods for Antibacterial Medical Attires

- AATCC test method 100
- AATCC test method 147
- ASTM E2149-01
- ISO 22610
  - Wet bacteria penetration tester

Water Resistance

Type	Surgical Gown	mbar	Cm (H2O)	Mean Cm(H2O)	Level
Disposable	Astound Standard 39515 (Cardinal Health L3)	79.30 74.00 78.70	80.89 75.48 80.27	77.33	3
	Standard surgical gown (Kimberly Clark)	76.30 73.30 72.30	77.83 74.77 73.75	73.97	3
Reusable	Standard surgical gown (St Joseph's gown)	24.90 27.60 24.50	25.40 28.15 24.99	26.18	2
Reusable	Biocidal Fabric (Lab researching)	2.10 0.70 0.80	2.14 0.71 0.81	1.21	NA

Wet Bacteria Penetration Results

ISO 22610

(1) Disposable Astound standard surgical gown (Cardinal Health L3)

	*X*1	X2	X3	X4	X5	*Z*	*IB*	*Mean IB*
S1	36	3	0	1	0	750	5.75	
S2	3	0	0	0	0	750	5.98	
S3	0	0	376	940	478	1800	5.03	5.66
S4	3	1	1	9	76	2200	5.95	
S5	11	5	62	130	437	1600	5.57	

(2) Disposable Standard Surgical Gown (Kimberley Clark) L3

	*X*1	X2	X3	X4	X5	*Z*	*IB*	*Mean IB*
S1	230	4	6	69	123	2200	5.45	
S2	37	47	116	416	595	1250	5.13	
S3	1200	123	464	121	15	1633	3.71	4.51
S4	250	213	670	1250	1250	1250	4.39	
S5	400	910	1070	1980	1787	723	3.88	

Wet Bacteria Penetration Results

ISO 22610

Reusable Surgical Gown (St. Joseph's regional hospital)

I. One layer gown fabric

	*X*1	X2	X3	X4	X5	*Z*	*IB*	*Mean IB*
S1	1267	1680	760	312	1256	767	3.15	
S2	853	812	438	267	201	1210	3.46	
S3	501	820	753	910	807	1505	3.99	3.70
S4	652	753	705	808	751	1510	3.92	
S5	753	650	904	1505	1020	1523	3.94	

2. Two layers gown fabric

	*X*1	X2	X3	X4	X5	*Z*	*IB*	*Mean IB*
S1	10	0	0	12	13	≧1500	0.0074	5.97

Wet Bacteria Penetration Results

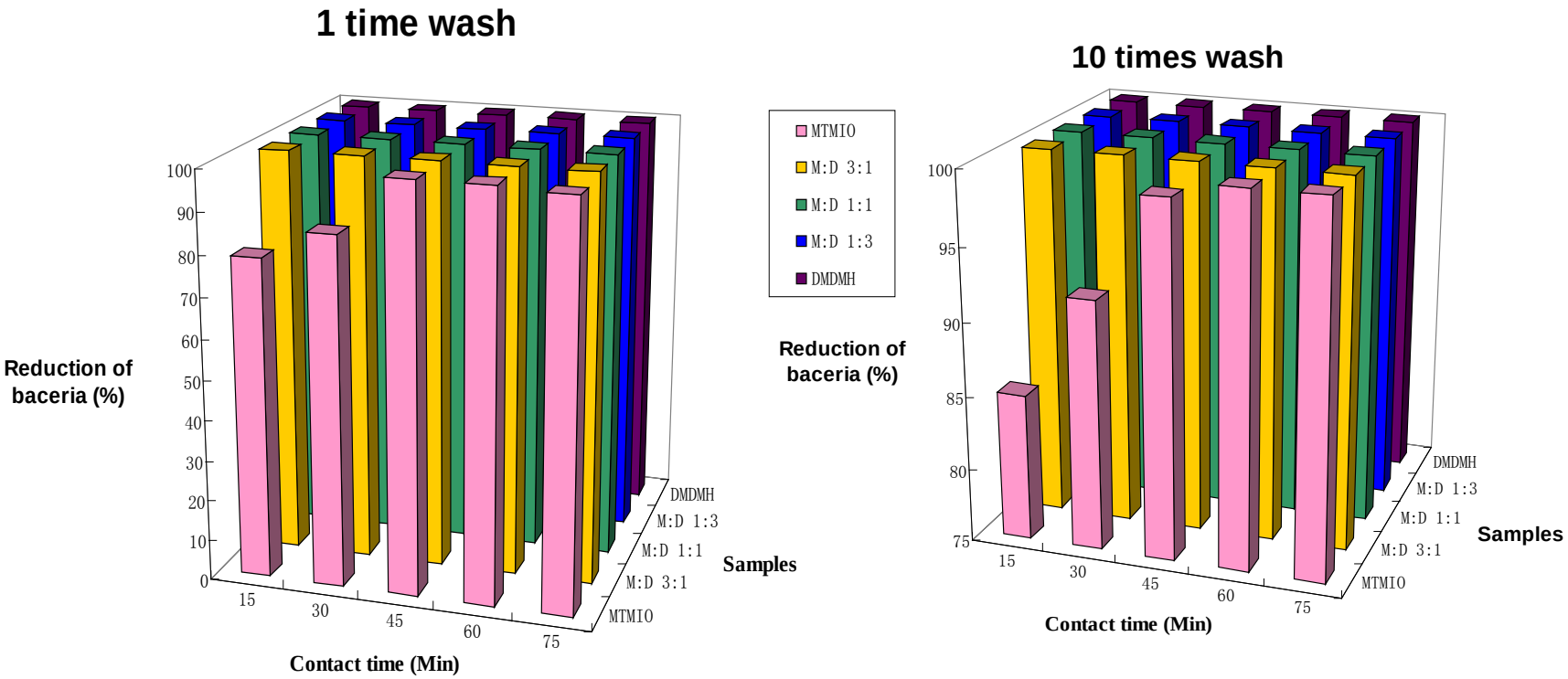
ISO 22610

Biocidal Fabric (Lab researching Fabric)

	*X*1	X2	X3	X4	X5	*Z*
Control-10^4	**≧1500**	**≧1400**	**≧1600**	**≧1500**	**≧1300**	**≧2000**
S1	**0**	**0**	**0**	**0**	**0**	**0**
Control-10^5	**≧1500**	**≧1500**	**≧1500**	**≧1500**	**≧1500**	**≧1500**
S2	**0**	**0**	**0**	**0**	**0**	**0**
S3	**0**	**0**	**0**	**0**	**500**	**1500**
Control-10^6	**720**	**603**	**447**	**324**	**239**	**277**
S4	**0**	**0**	**0**	**0**	**0**	**0**
S5	**0**	**0**	**0**	**0**	**0**	**0**

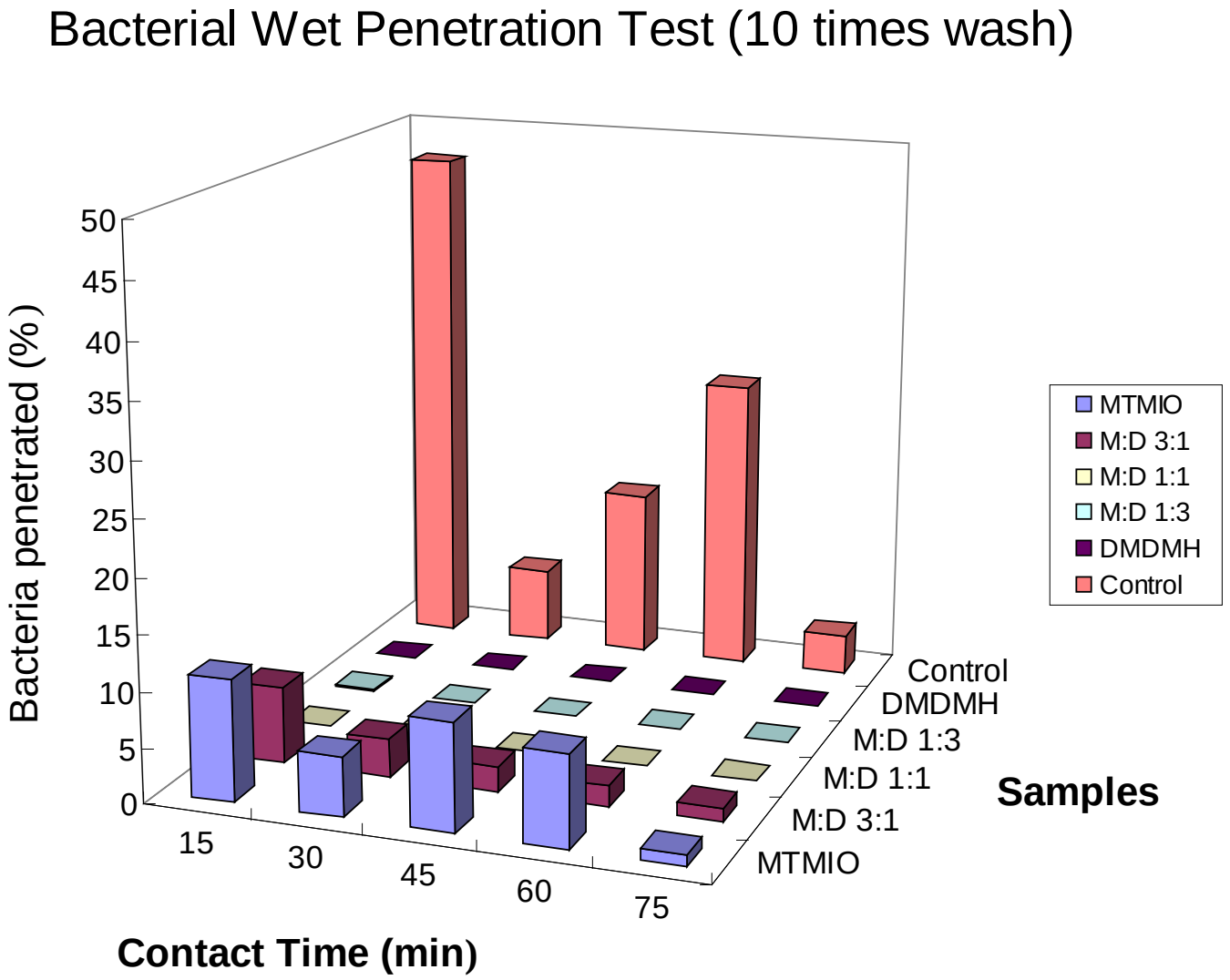
AATCC Test Method 100

Bacterial Reduction



Wet Penetration of Bacterium

ISO 22610



Antimicrobial Functions

- **Biostatic functions**
  - Inhibit growth of microorganisms
  - Prevent materials from bio-degradation
  - Odor-control textiles

- **Biocidal functions (Antibacterial)**
  - Kill microorganisms completely and rapidly
  - Protect wearers of textiles from biological attacks
  - Odor-free textiles

- **Selection requirements**
  - Personal protection should use biocidal textiles
  - Consumer products could use biostatic materials

Biocidal (Germicidal) Functions*

- **Sterilization**
  - **Complete elimination or destruction of all forms of microbial life**
- **Disinfection**
  - ***High Level Disinfection*** **-to destroy all microorganisms, with exception of bacterial spores**
  - ***Intermediate Level Disinfection*** **-to inactivate Mycobacterium tuberculosis, vegetative bacteria, most viruses and most fungi, but not necessarily bacterial spores**
  - ***Low Level Disinfection*** **– to kill most bacteria, some viruses, and some fungi**
- **Sanitization**
  - **Reduce microbial population on an inanimate object**

*APIC Guideline for Selection and Use of Disinfectants, 1996

Criteria's of Biocidal Medical Use Textiles

- **Quick kill to a broad spectrum of pathogens including *bacteria, yeasts, fungi, and viruses***
- **Non-selective to and no immunity from germs**
- **Non-toxic to wearers and non-irritating to skin**
- **Durable against repeated laundry and sterilization**
- **Rechargeable if the function is lost in laundry or use**

Durability Requirements

- Washing durability-50 home laundering
- Storage durability-3-6 months of shelf life
- Weathering and UV resistance

Challenges:

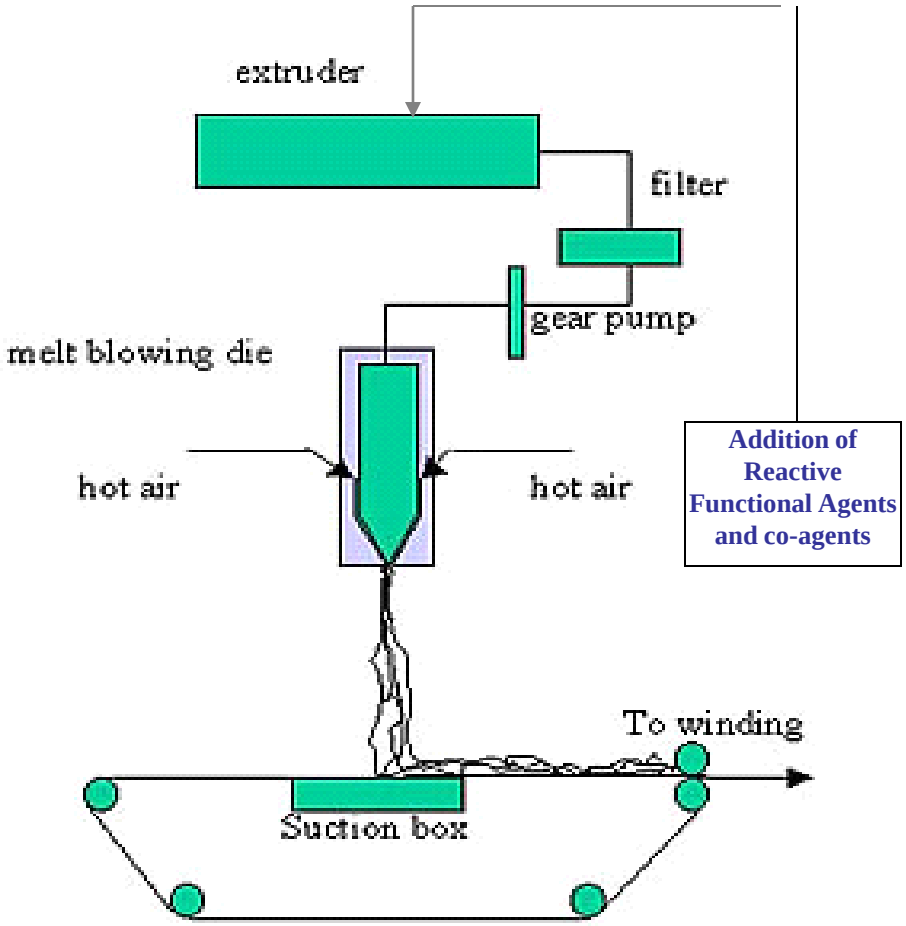
1. Antimicrobial functions always consume biocides
2. Biocidal surfaces can be covered by dead bacterial cells or dusts

Incorporation of Biocides to Textiles

- Fiber
  - Finishing
  - Fiber extrusion → Additives in fiber extrusion; Reactive extrusion
- Yarn-finishing
- Fabric-finishing or coating
- Garment-finishing or coating

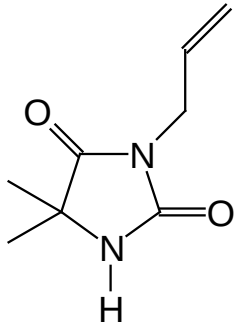
Biocidal Polypropylene Fibers

- Design of a manufacturing technology to carry out graft polymerization during fiber spinning
- Preparation of biocidal fibers and nonwoven fabrics using the above process
- Direct preparation of reusable and rechargeable biocidal N95 respirators and face masks

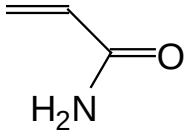


UCDAVIS

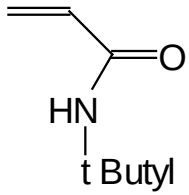
Vinyl Monomers Employed



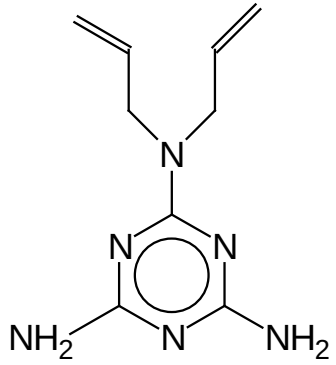
3-allyl-5,5-dimethylhydantoin (ADMH)



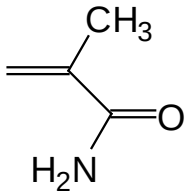
Acrylamide (AM)



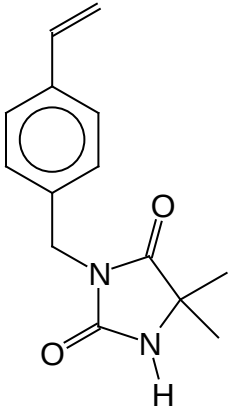
n-t-butyl acrylamide (t-BAM)



N,N-diallylmelamine



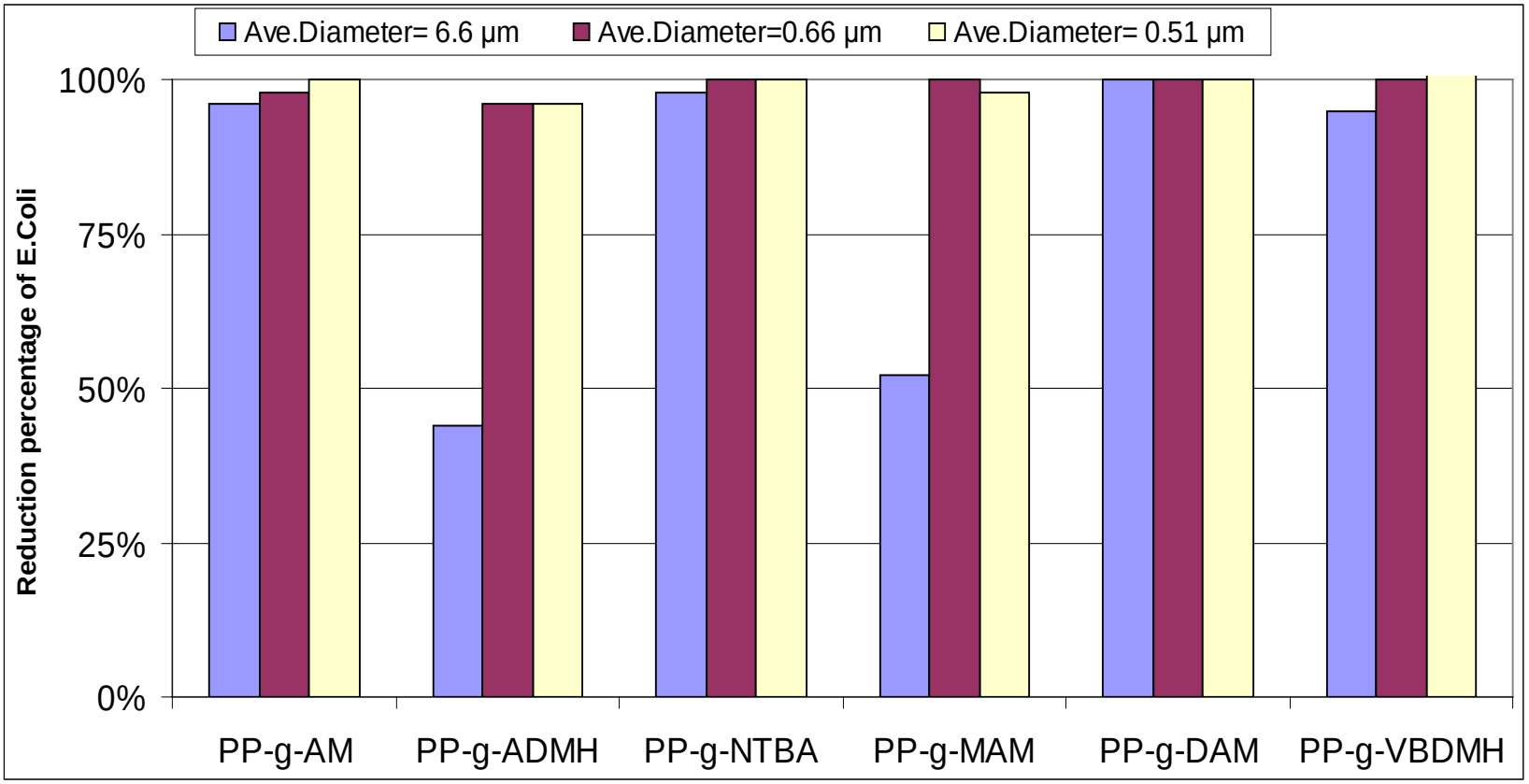
Methacrylamide (MAM)



3-vinylbenzyl-5,5-dimethylhydantoin (VBDMH)

Vinyl monomers containing cyclic and acyclic imide, amide and amine bonds can be employed in this reaction

Relationships Between Fiber Size and Biocidal Efficacy

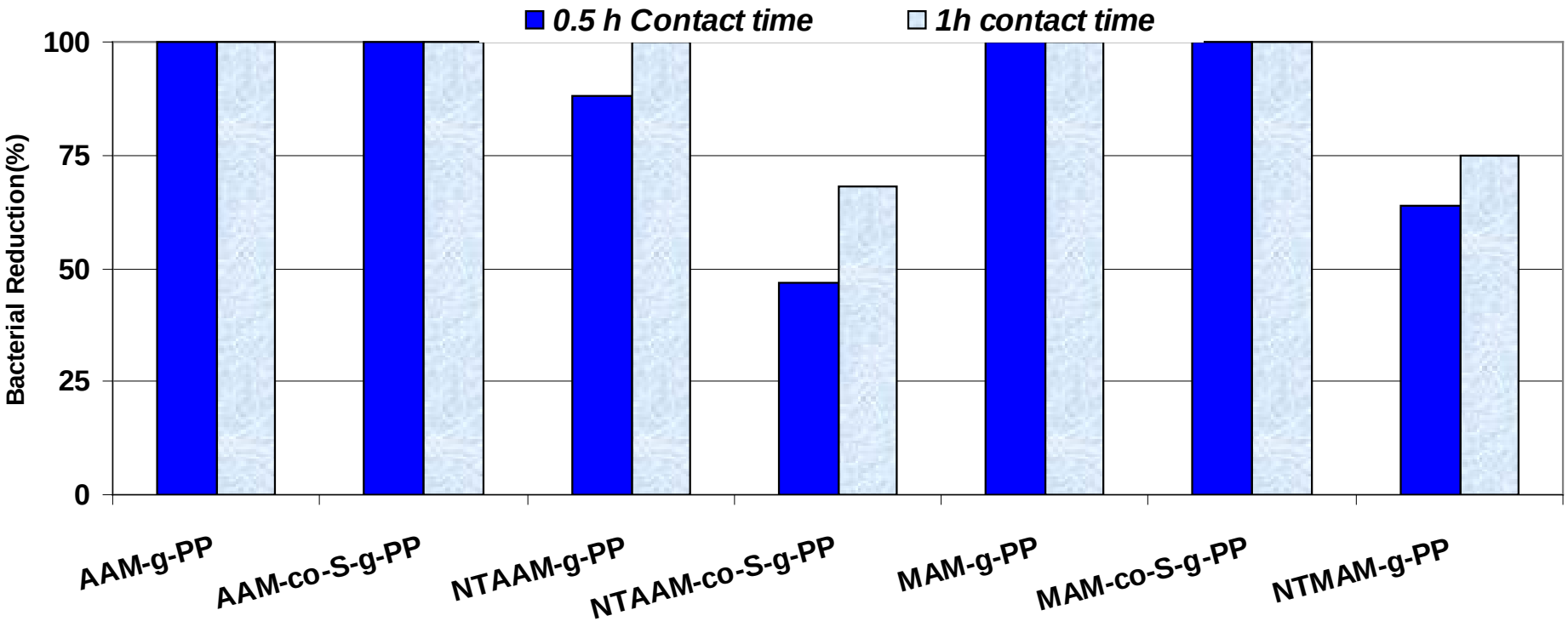


The chlorinated PP fibers were challenged by one mL of E. coli with concentration of $10^{5\text{-}6}$ CFU per mL

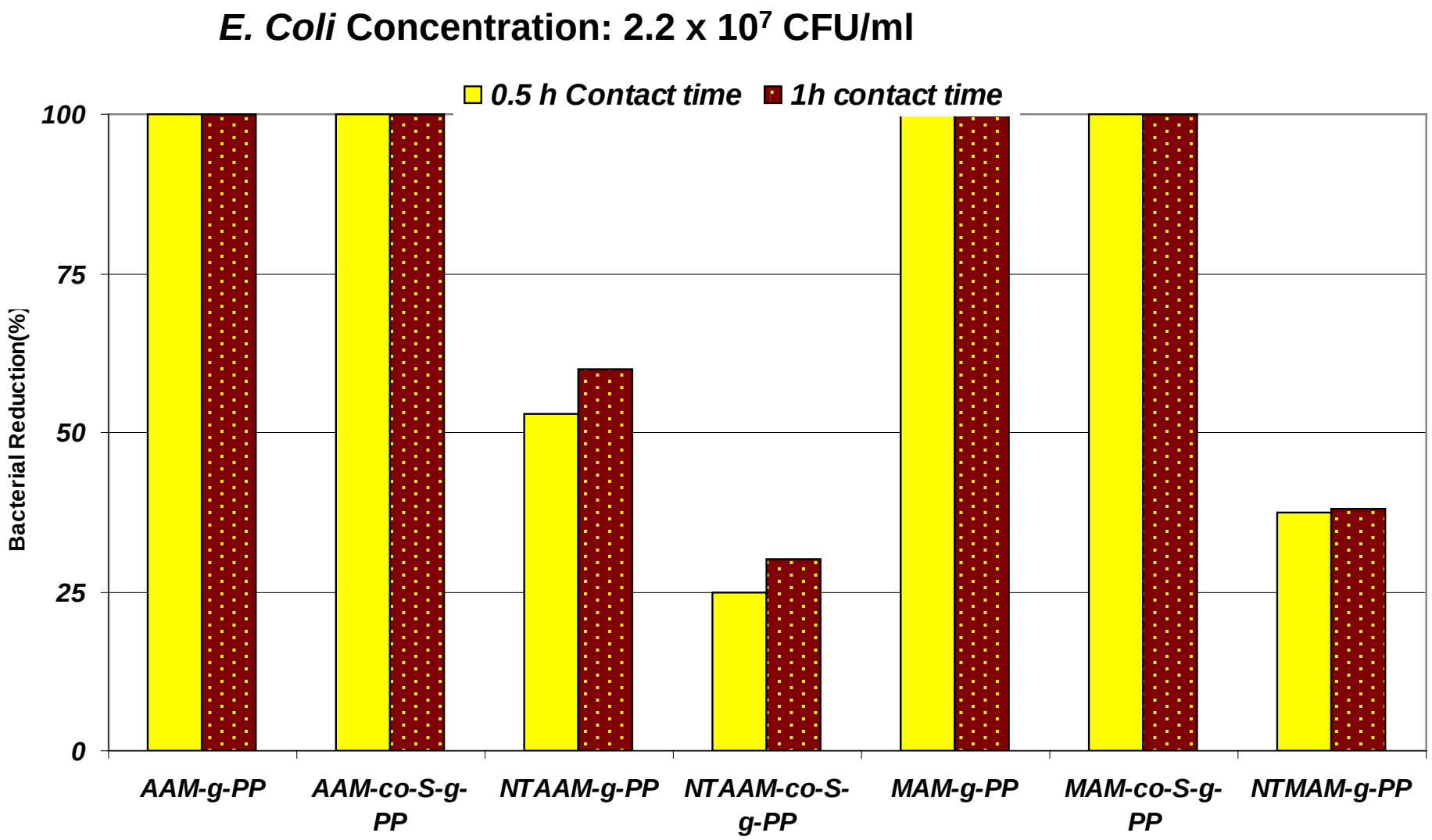
Badrossamay *and* Sun, *European Polymer Journal 2008,* V44, 733-742

Antimicrobial Activities

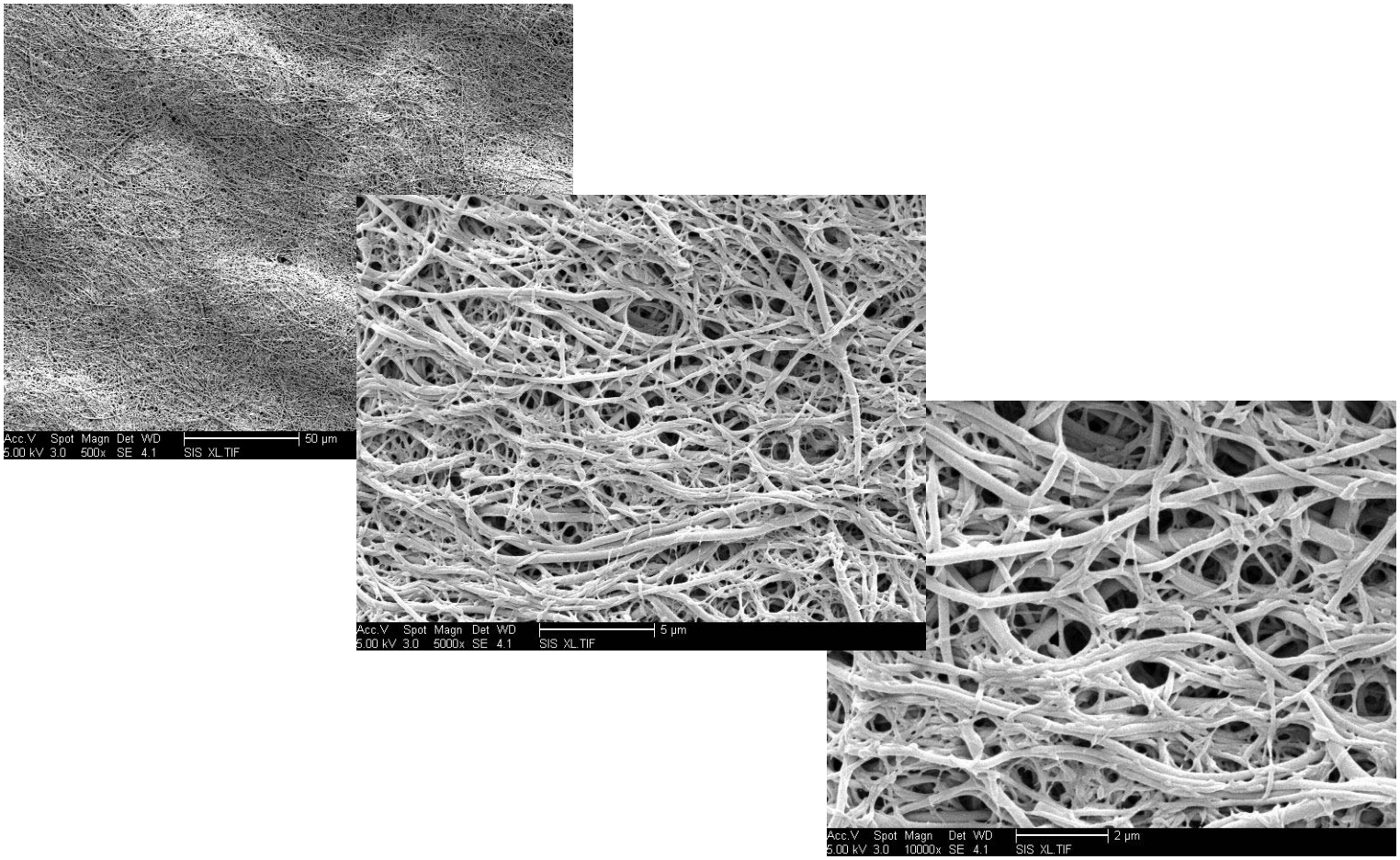
***E. Coli* Concentration: 1.5 x 10^5 CFU/ml**



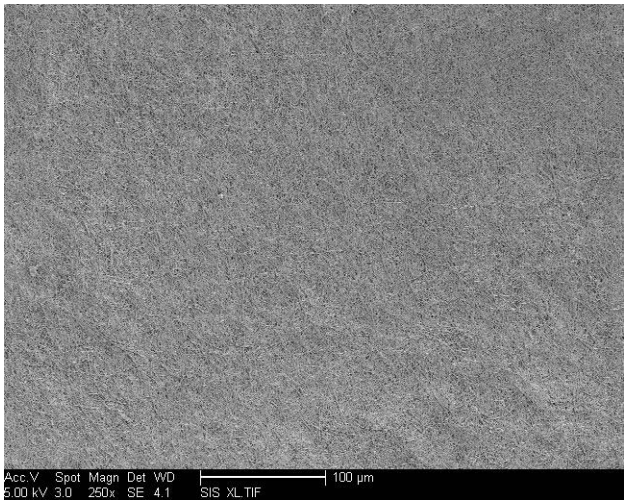
Antimicrobial Activities

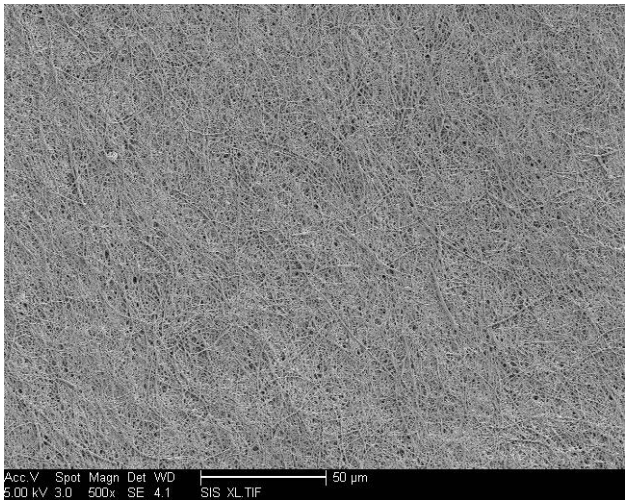


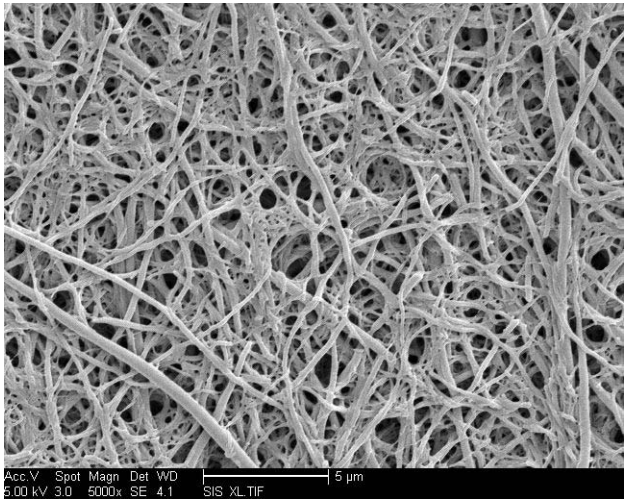
Novel Biocidal Nonwoven

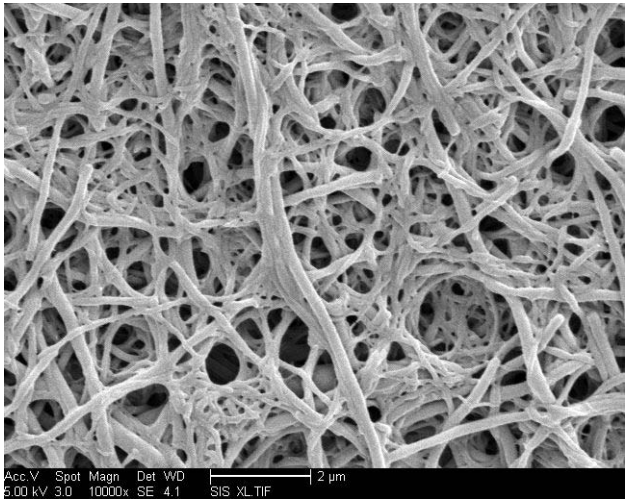


Novel Biocidal Nonwoven



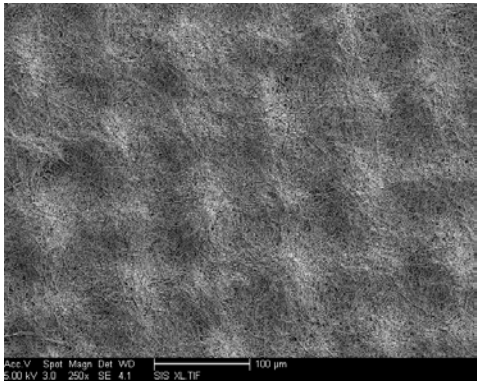


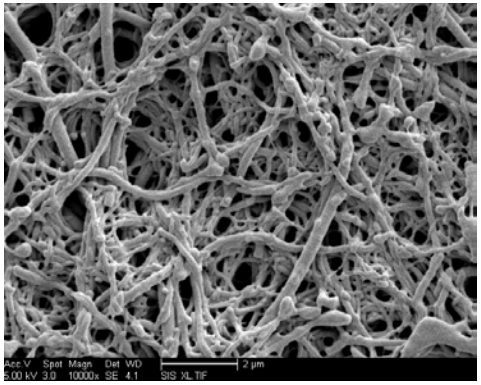




Nanofiber Selections

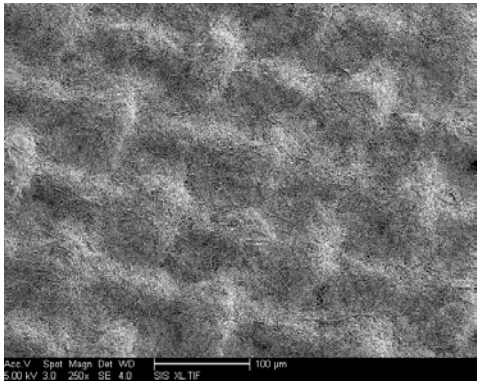
- **Hydrophilic membrane-Poly (Vinyl alcohol-co-ethylene) (PVA-co-PE)**

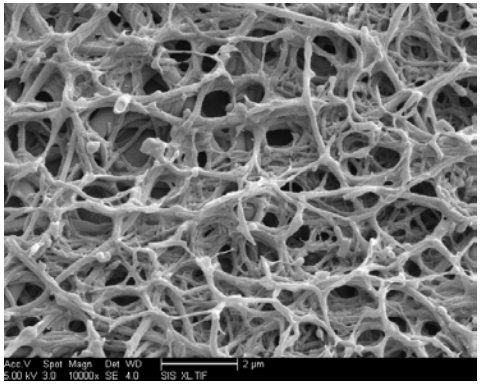




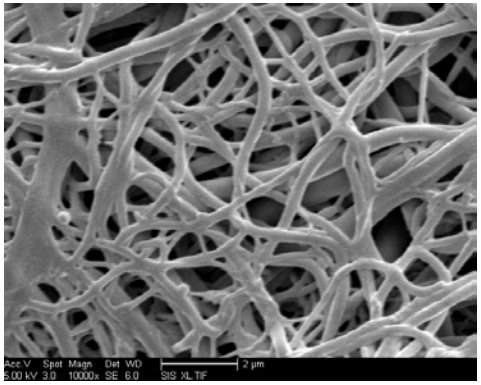
- **Hydrophobic membrane-Poly (trimethylene terephthalate)**

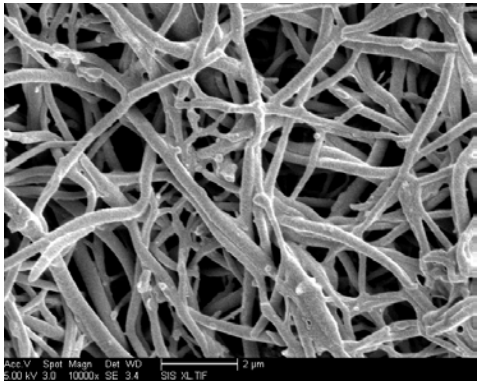
(PTT)

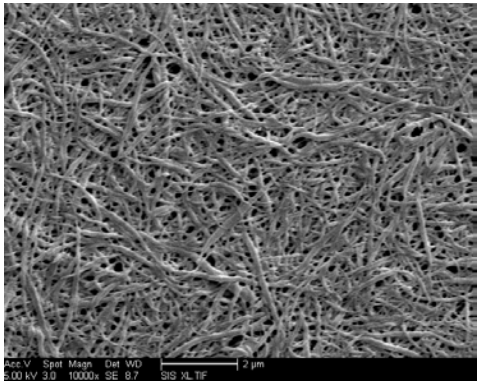




- **Polypropylene (PP)**
- **PP-g-DAM (Diallylmelamine)**
- **PE-co-GMA (Glycidyl Methacrylate)**







Acknowledgements

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C02-CD06 and M06-CD04

Defense Threat Reduction Agency

(HDTRA1-08-1-0005)


SOFT TOYS SPREAD INFECTION SAY RESEARCHERS
YOUR DAUGHTER'S READY TO GO HOME, MRS BROWN... BUT HER TEDDY BEAR WILL HAVE TO STAY A FEW MORE DAYS
STAYSKAL 1/02
TAMPA TRIBUNE