Antibacterial Poly(ethylene terephthalate)(PET)

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April 17, 2009

Outline

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- Project background
  - Nosocomial infection
  - Survival of microorganisms on textiles
  - Antibacterial polyester
  - Antimicrobial agents
  - Reusable biocidal function
  - Modification method
- Experiment results
  - Synthesis and characterization
  - Influence of experimental parameters
  - Properties
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Project Objectives

In this project I aim to

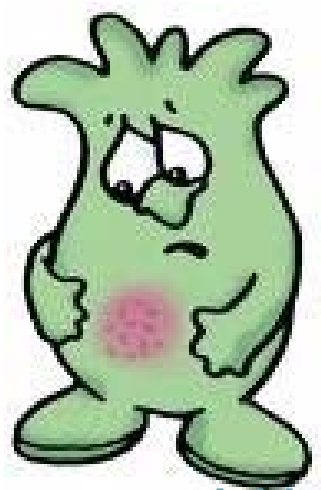
- Synthesize regenerable antibacterial PET for medical applications such as nurse uniforms, surgical gowns and protective drapes.
- Optimize the components and condition for polymerization and treatment
- Test the the properties especially the antimicrobial performance of the treated polyester and establish the relationship between variables and properties

Nosocomial Infection

Canada—estimated 220,000 infections acquired in health care facilities each year

—8,000 deaths attributable to these infections annually[1]

Antibiotic resistance



Why am I sick?

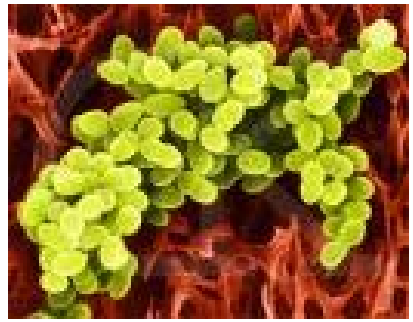
http://eemb40.blogspot.com/2009/02/nosocomial-infection-in-canada.html **accessed on April 3**

Survival of microorganisms on textiles

- Neely et al did experiments--gram-positive bacteria, gram-negative bacteria and fungi on various common textiles used in hospital.

-- 10 ^{4} to 10 ^{5} CFU/ml bacteria or fungi per swatch, they could survive at least 1day and some of gram-positive bacteria stayed alive for more than 90 days

- **The contaminated textile materials serve as one of major sources of infectious diseases.**



Staphyloccocus Aureus

Soil, dust, solutes from sweat on textile

Nutrient sources for microorganisms

Neely, A.N., Maley, M.P. (2000). Survival of enterococci and staphylococci on hospital fabrics and plastic. *J. Clin. Microbiol.* 38,724
Neely, A.N. (2000). A survey of Gram-negative bacteria survival on hospital fabrics and plastics. *J. Burn Care Rehabil.* 21,523.
Neely, A.N., Orloff, M.M. (2001). Survival of Some Medically Important Fungi on Hospital Fabrics and Plastics. *J. Clin. Microbiol.* 39,3360.

Polyester application and advantages

- **Polyester - reusable medical textiles**

  Compared to disposable textiles (such as cotton)

  -Reduce waste

  -Cost half as much

  -70% more effective protections

- **Advantages**

  . Ease of processing

  . Low production cost

  . Thermal stability and durability---reusable ---save energy and cost

http://cms.h2e-online.org/ee/waste-reduction/waste-minimization/textile/reusedispose/

Antibacterial reagents used in Textiles

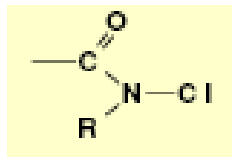
- **Metals and metal salts**

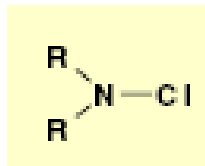
---- Effective and durable but expensive

- **Quaternary ammonium salts(QAS)**

---- Retains its antimicrobial ability as long as the compound is attached to textiles, not very effective and suffer from a possible bacterial resistance problem.

- ***N*-Halamines**





---- One or more nitrogen - halogen covalent bonds

---- Formed by the chlorination or bromination of imide, amide, or amine groups

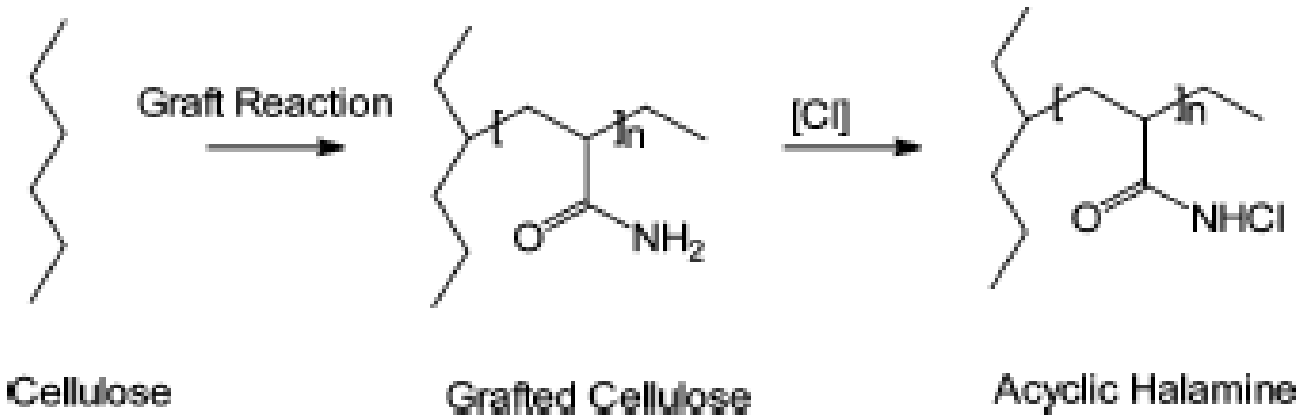
---- Effective as broad-spectrum disinfectants

---- **Regenerable! Fit for reusable polyester**

Regenerable antimicrobial cotton cellulose with N-halamine

- **N-halamine technique were employed successfully on cotton cellulose.**

Scheme 1. Grafting AM and Chlorination of AM Grafted Polymers



Liu, S., Sun, G. (2006). Durable and Regenerable Biocidal Polymers: Acyclic N-Halamine Cotton Cellulose. *Ind. Eng. Chem. Res.* 45, 6477-6482

Modification of polyester

Challenge: **Not so easy as chemical modification of cotton!**

- No active functional group on polyester surface

- Little quantity of radicals permitted on macrochains

- Monomer diffusion is poor: long chain and high crystallinity, hydrophobicity

Possible methods to immobilize antimicrobial reagents on polyester:

- Blending

- Modification via chemical reaction

- Radical grafting polymerization

Examples of polyester modification

Sample	Total kill time		Comments
	S.Aureus	E.coli	
Copper Oxide Impregnated polyester[1]	2h	1h	Not very effective
Polyester with N-halamine siloxane coatings[2]	5min	30min	Effective; 18% strength loss Hydrolysis and frictional loss of coating
Bacteria concentration 10^5-10^6 CFU/ml			

Photo-initiated UV grafting ⟶ our choice

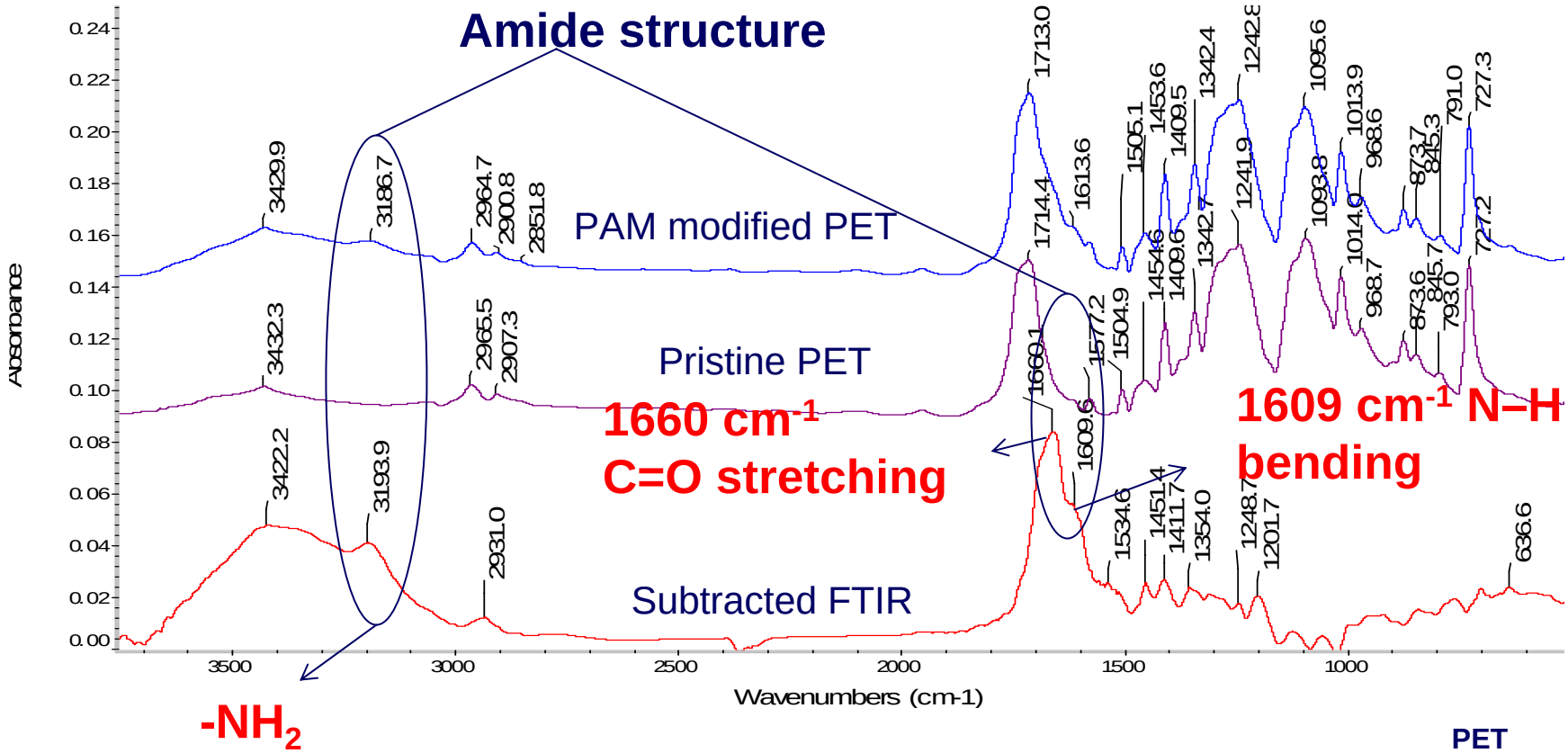
- Simple, clean, little influence to the mechanical properties of the polymer, and could accomplish one side modification

1. J Gabbay, G Borkow (2006). Copper Oxide Impregnated Textiles with Potent Biocidal Activities, *Journal Of Industrial Textiles*(35), 4,323.
2. Ren, X. (2008,), Kocer H. B., Kou L., Worley, S. D., Broughton, R. M. , Tzou, Y. M., Huang, T. S. Antimicrobial Polyester, *Journal of Applied Polymer Science*, 109, 2756–2761

Experiment Part

- **Synthesis**
  - Possible mechanism
  - Experiment process
  - FTIR
  - Extraction test
- **Influence of experimental parameters**
  - Monomer concentration
  - Chlorination condition
- **Properties**
  - XPS(X-ray photoelectron spectroscopy)-Element distribution
  - SEM(Scanning electron microscope)-Surface Morphology
  - Antibacterial test
  - Regenerability study

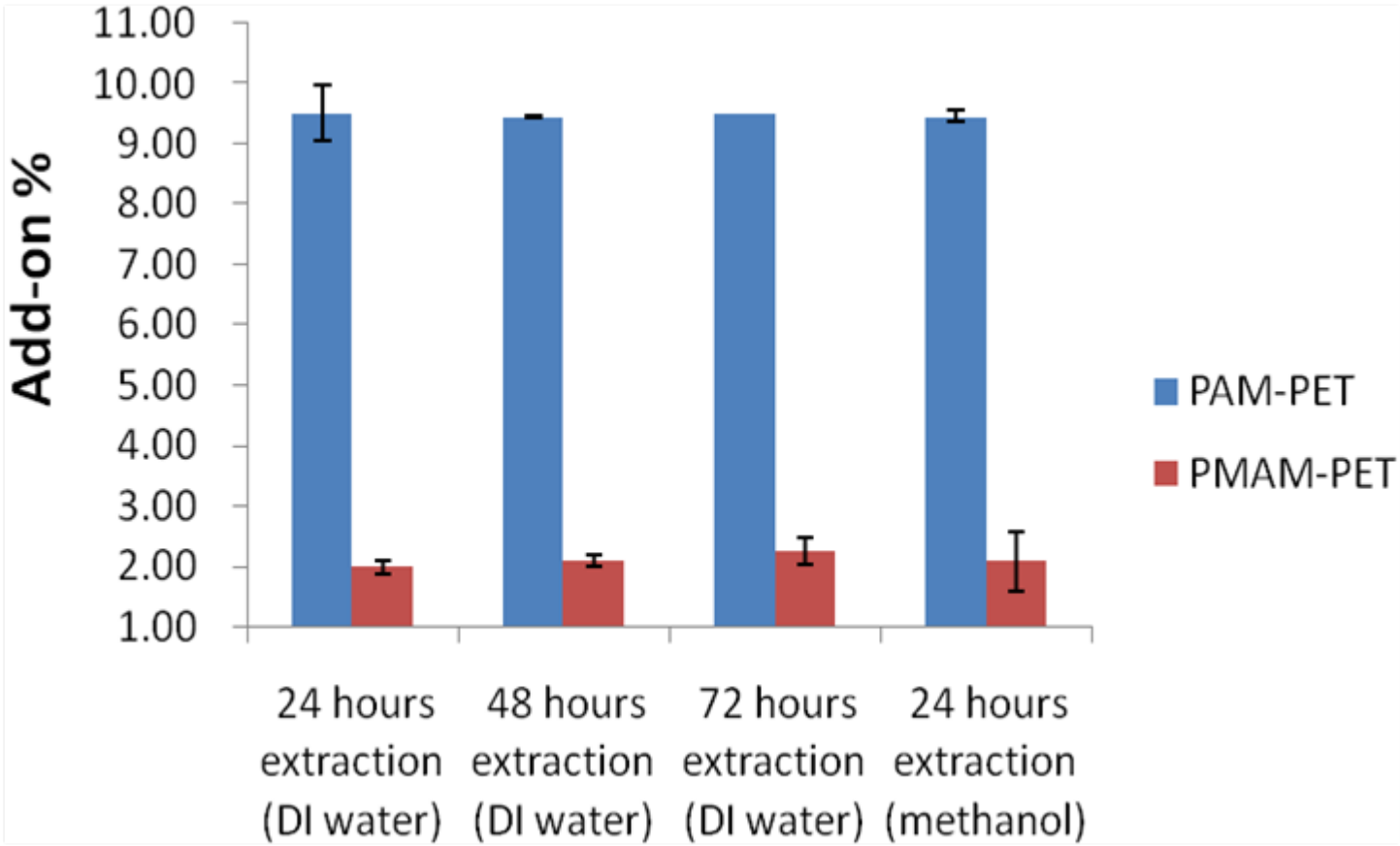
FTIR



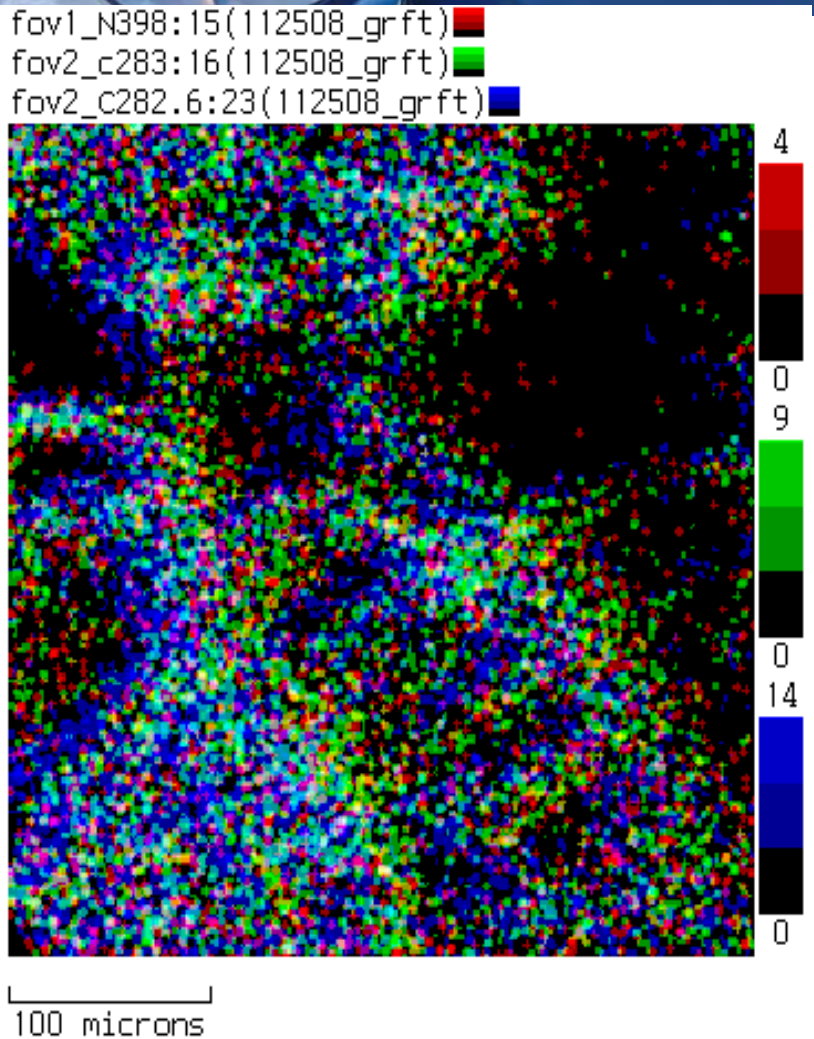
Fourier transform infrared spectroscopy (FTIR) results proved the successful grafting of AM on polyester.

Extraction test

Grafting %



XPS image



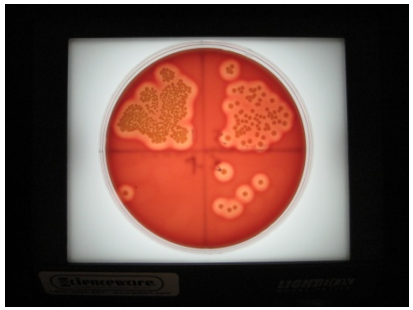
XPS image of PAM modified PET

Element distribution on surface

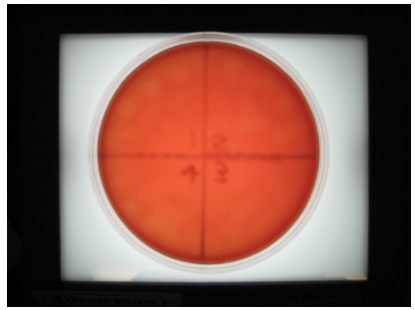
Red: N element

Amide functional groups distribute evenly on polyester.

Antibacterial test



HA-MRSA 70527 Pristine Fabric



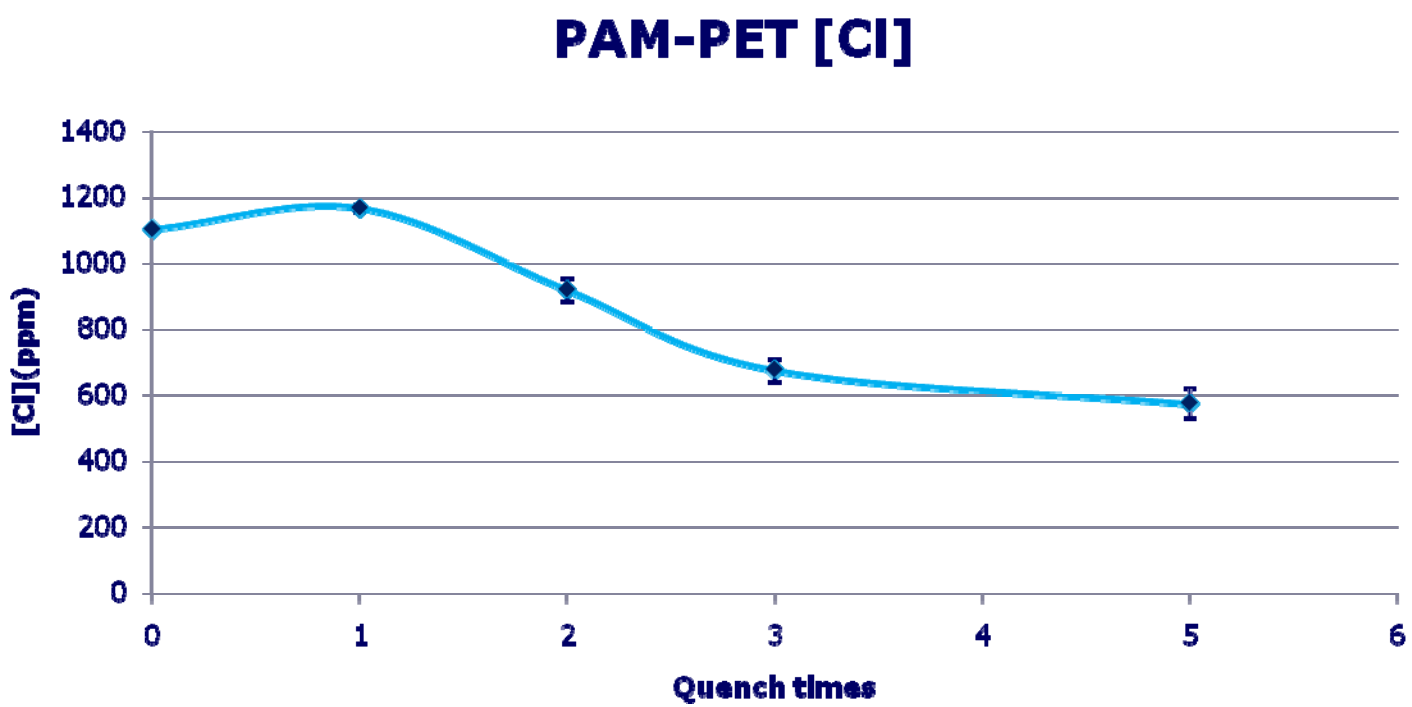
Treated PET

Antibacterial AATCC test method 100

Grafted PET	Active Chlorine(ppm)	Bcteria	Reduction of bacteria at contact times(%)		
			5min	10min	15min
PAM-PET	1398±12	Other 4	-----	>90.57%	99.999%
PAM-PET	1359±32	HA-MRSA 70527	-----	99.999%	99.999%
PAM-PET	1158±17	HA-MRSA 70527	65.92%	96.21%	99.999%

AATCC test method 100, 5 kinds of bacteria were challenged(CA-MRSA 40065, HA-MRSA 70527, S.Aureus ATCC 25923 , MDR ESBL 70094 and MDR P. Aeruginosa), bacteria concentration 10^5-10^6 CFU/ml

Regenerability of PAM-PET



Acknowledgement

- University of Manitoba
- Department of Textile Sciences
  - Dr Song Liu
  - Dr Wen Zhong
  - Dr Tammi Feltham
  - Dr Lena Horne
- Dr. George Zhanel at the Department of Infectious Diseases

- Financial support from Manitoba Medical Service Foundation
- The Institute of Textile Science