



Textile Functionalization and its Effects on the Release of Silver Nanoparticles into Artificial Sweat

Heike Romanowski

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1. Background Functionalization of Textiles
2. Experimental Setup
3. Results
4. Conclusion

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Nano Textiles – Application Examples

Properties of nano textiles	Nanomaterial
UV protection	TiO ₂ ZnO
Thermally conductive/insulating	CNT
Moisture-absorbing	TiO ₂
Antibacterial	Ag TiO ₂ ZnO
Self-cleaning/dirt and water repellent	CNT SiO ₂ TiO ₂

Risks (Nano)-silver

Risks:

- Silver ions can damage living cells
- Resistance to silver and antibiotics in microorganisms

Recommendation:

Avoid (Nano)-silver in food and everyday products

Motivation

Better understanding of:

- Consumer Ag exposure
- Ag release from textile
- **Influence of the functionalization**



Different functionalization techniques

composites	coating
Particles embedded within textile fiber	Particles on fiber surface

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Experimental Setup: 10 different Textiles

4 commercially available

- Towel
- Socks
- Sports shirt
- Pillow



6 laboratory-prepared

- 2 Ag composites
- 3 Ag coatings
- 1 untreated

Experimental Setup

Characterization of Textiles

Visualization of NPs on textile surface

- environmental scanning electron microscopy (**ESEM**) with energy dispersive X-ray spectroscopy (**EDX**)
- time-of-flight secondary ion mass spectrometry (**ToF-SIMS**)

Quantification of total Ag Content

- Digested in microwave oven / **ICP-MS**

Experimental Setup

Characterization of Textiles

- | | |
|---|--|
| Visualization of NPs on textile surface | <ul style="list-style-type: none">• environmental scanning electron microscopy (ESEM) with energy dispersive X-ray spectroscopy (EDX)• time-of-flight secondary ion mass spectrometry (ToF-SIMS) |
| Quantification of total Ag Content | <ul style="list-style-type: none">• Digested in microwave oven / ICP-MS |

Migration

- | | |
|--------------------------------------|---|
| | Textile covered with artificial sweat (pH 5.5 and pH 8) for 24h/48h |
| Release of total Ag into sweat | → Artificial sweat analyzed with ICP-MS |
| Release of particulate Ag into sweat | → Artificial sweat analyzed with spICP-MS (single particle mode) |

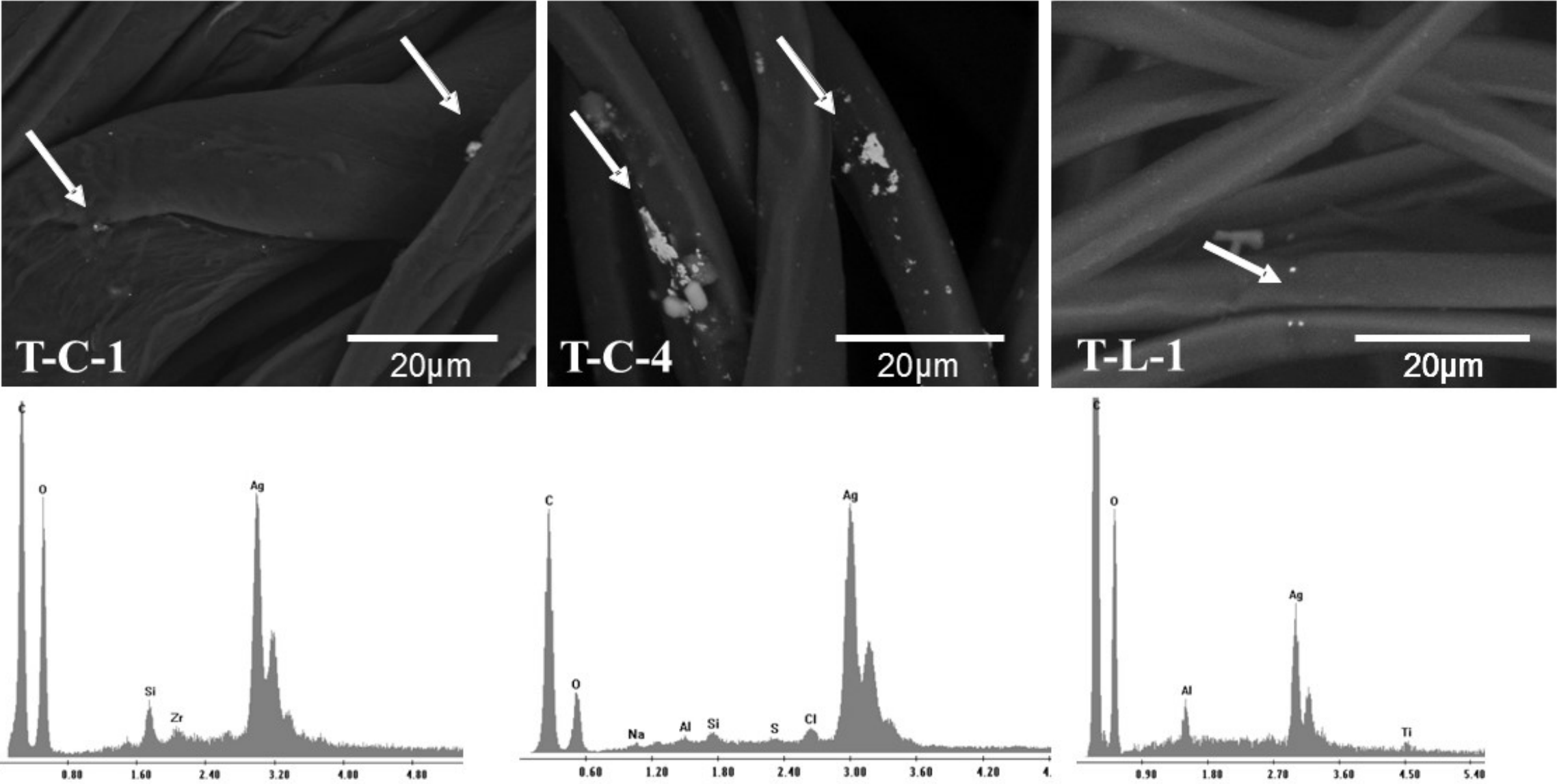
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Characterization of Textiles: Visualization of NPs on textile surface

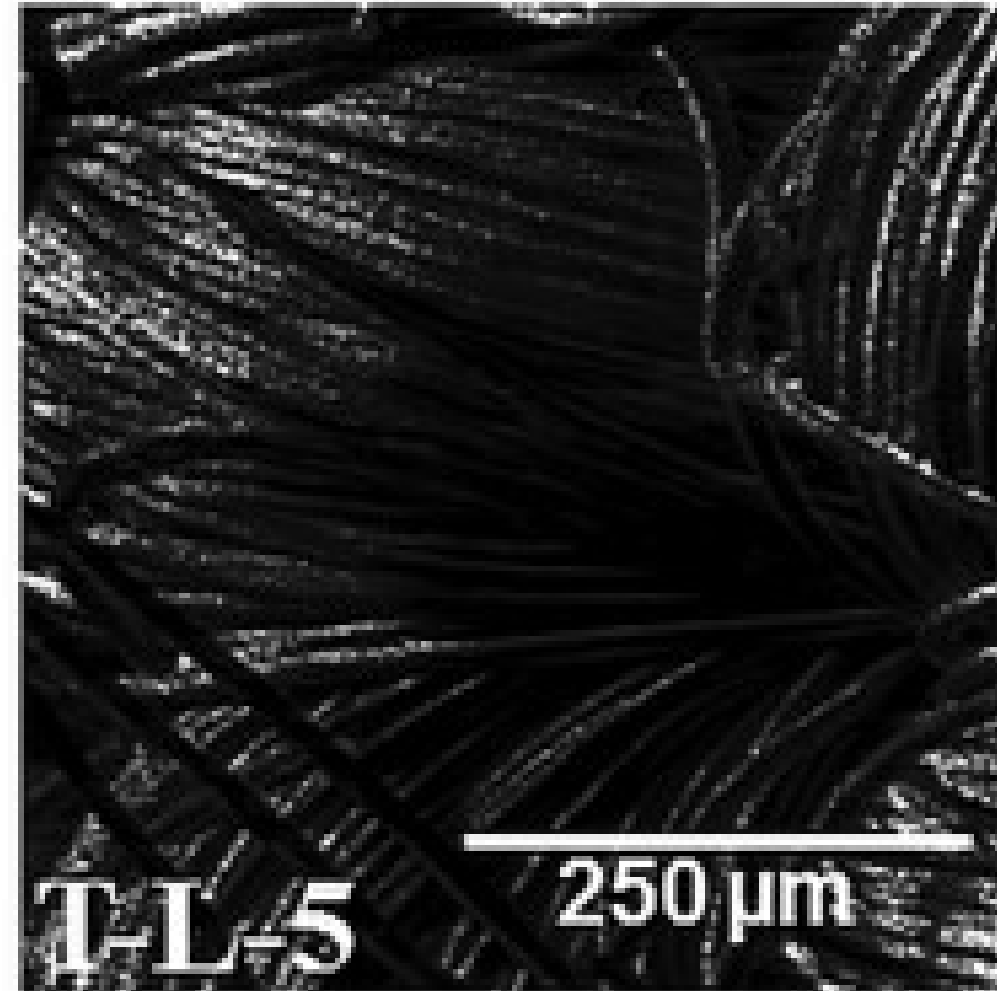
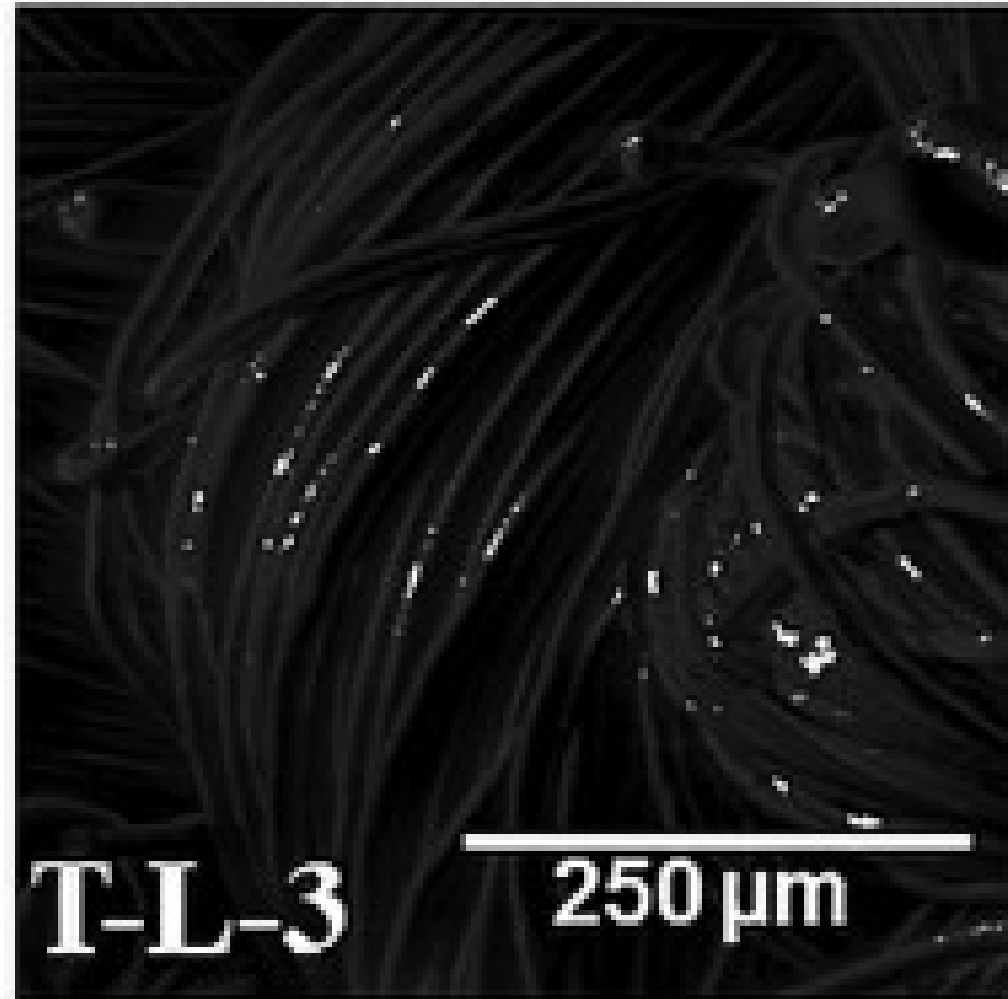
	Visualization of NPs on textile surface	Quantification of total Ag Content (mg/kg)
Towel	X	
Socks	✓ (a few particles)	
Sport shirts	✓	
Pillow	✓	
T-L-1 (composite)	✓	
T-L-2 (composite)	Not analyzed	
T-L-3 (coating)	✓	
T-L-4 (coating)	Not analyzed	
T-L-5 (coating)	✓	

Characterization: Larger numbers of Ag particles on commercial textiles compare to lab-prepared nano-composite



ESEM images with EDX-spectra of a pillow (T-C-1), a sports shirt (T-C-4) and a lab-prepared nano-composite textile (T-L-1).

Characterization: Difference between Ag-NP and AgCl coated textiles

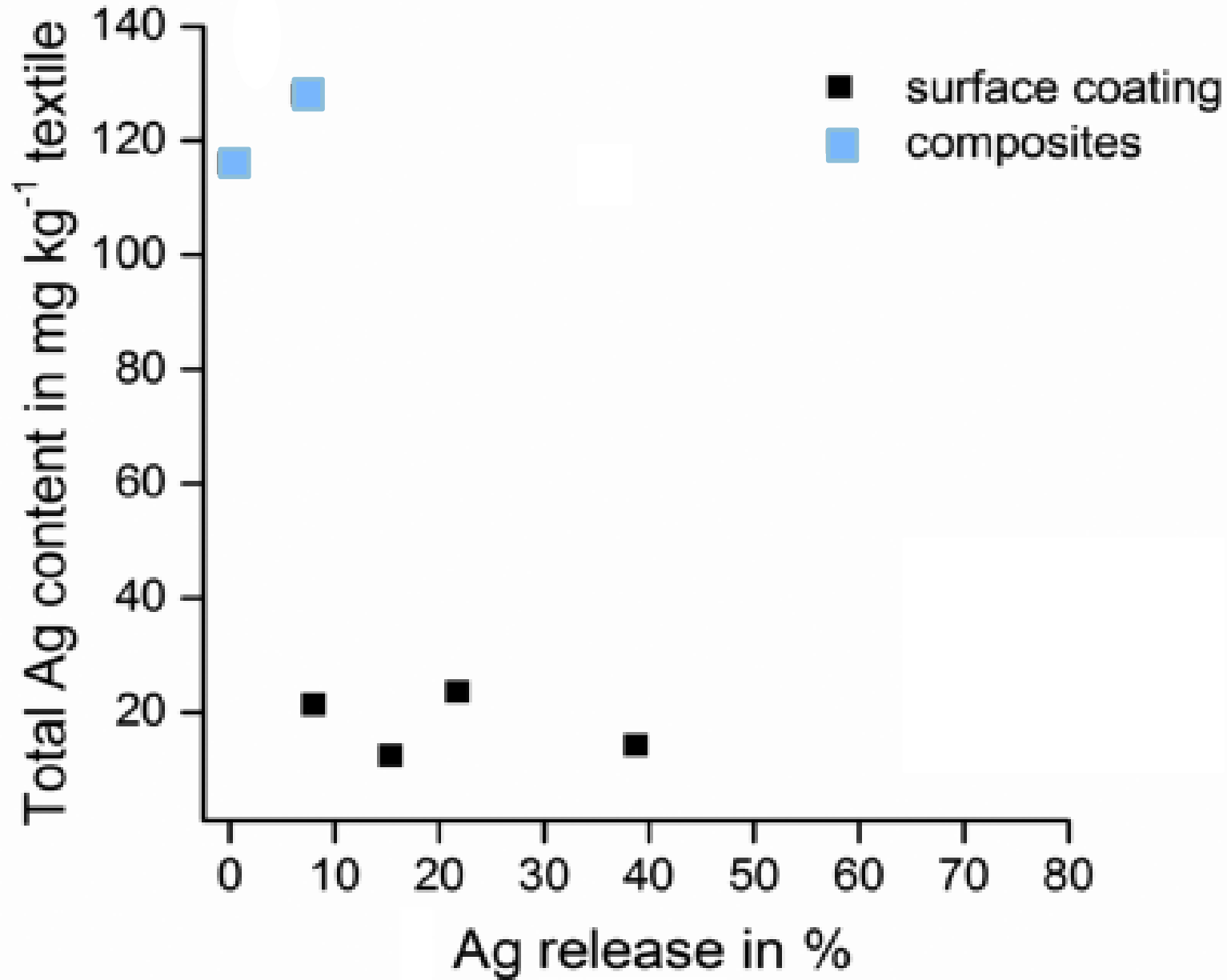


ToF-SIMS images of lab coated textiles
with large aggregates for nano-Ag (T-L-3) and a very thin film for AgCl (T-L-5)

Characterization of Textiles: Quantification of total Ag Content

	Visualization of NPs on textile surface	Quantification of total Ag content (mg/kg)
Towel	X	X
Socks	✓ (a few particles)	Below LOD
Sport shirts	✓	14.2
Pillow	✓	23.5
T-L-1 (composite)	✓	128.0
T-L-2 (composite)	Not analyzed	132.8
T-L-3 (coating)	✓	12.4
T-L-4 (coating)	Not analyzed	14.9
T-L-5 (coating)	✓	26.6

Migration into sweat:
Comparison Ag release from coating vs composites



Wagener et al. 2016, Environ. Sci. Technol., 2016, 50, 5927–5934

Migration into sweat: No significant pH-related influence

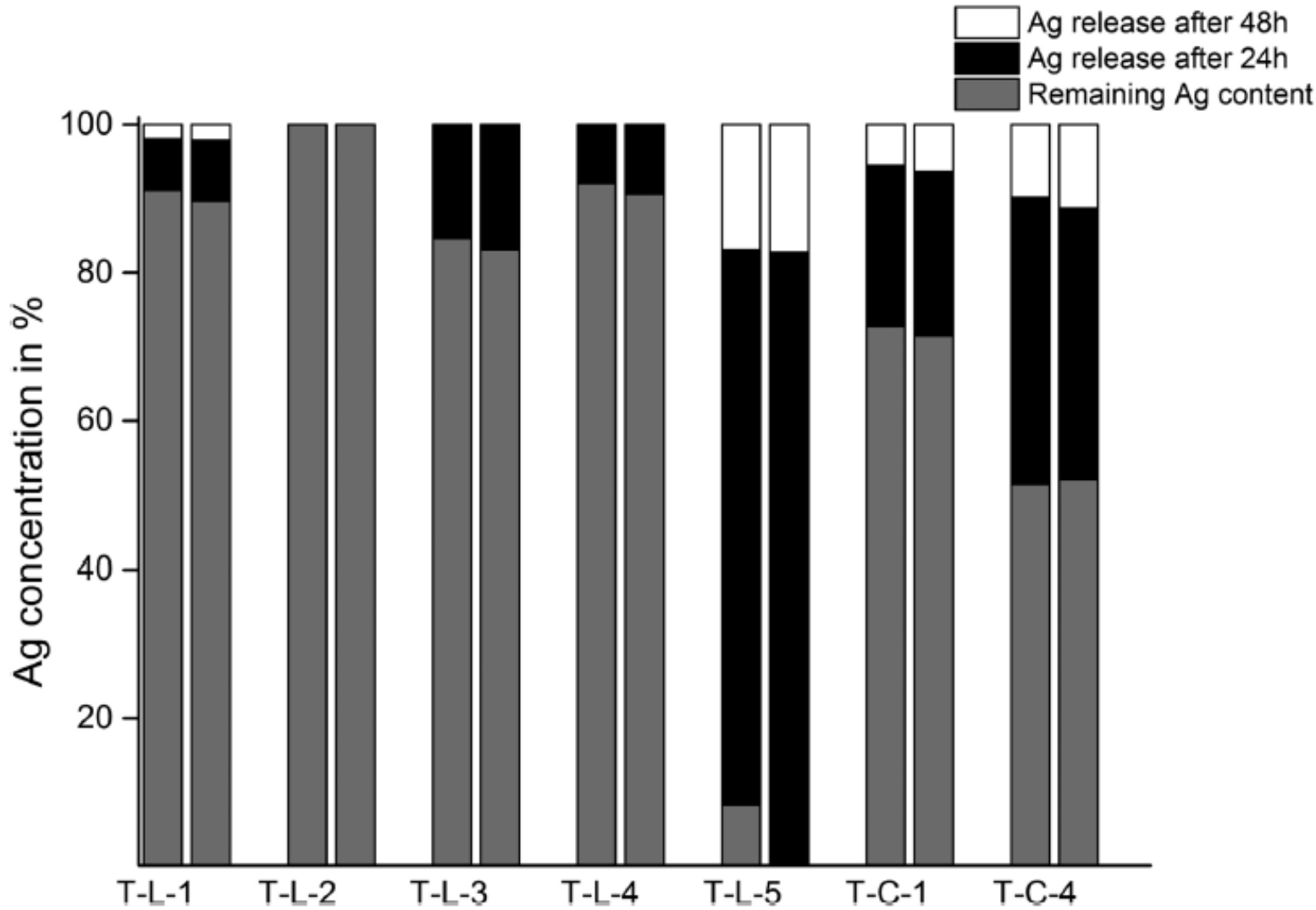


Figure 2. Relative Ag release of textiles. Left bars refer to acidic and right bars to alkaline sweat solution.

Wagener et al. 2016, Environ. Sci. Technol., 2016, 50, 5927–5934

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Conclusion

- Ag functionalized textiles release Ag
- Predominantly release of ions
- But also particulate Ag was identified
- Functionalization type influences released amount
 - Higher release for coated textiles vs nanocomposites



Thank you for your attention!

Heike Romanowski

Bundesinstitut für Risikobewertung

Abteilung 7: Chemikalien- und Produktsicherheit

Fachgruppe 75: Produktbeschaffenheit und Nanotechnologie

Max-Dohrn-Straße 8-10, 10589 Berlin

Telefon 030 - 184 12 - 27524

heike.romanowski@bfr.bund.de