



Antimicrobial Polymers

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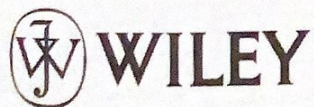
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9.1 INTRODUCTION

The innate immune response, which involves an interactive network of cellular and molecular systems responsible for recognizing and eradicating pathogens

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138. Pasquier, N., Keul, H., Heine, E., Moeller, M., Angelov, B., Linser, S., Willumeit, R. (2008). Amphiphilic branched polymers as antimicrobial agents. *Macromolecular Bioscience*, *8*, 903–915.
139. Lichter, J. A., Van Vliet, K. J., Rubner, M. F. (2009). Design of antibacterial surfaces and interfaces: Polyelectrolyte multilayers as a multifunctional platform. *Macromolecules*, *42*, 8573–8586.
140. Kenawy el, R., Worley, S. D., Broughton, R. (2007). The chemistry and applications of antimicrobial polymers: A state-of-the-art review. *Biomacromolecules*, *8*, 1359–1384.
141. van't Hof, W., Veerman, E. C., Helmerhorst, E. J., Amerongen, A. V. (2005). Antimicrobial peptides: Properties and applicability. *Biological Chemistry*, *382*, 597–619.
142. Li, Q., Lawrence, C. B., Maelor Davies, H., Everett, N. P. (2002). A tridecapeptide possesses both antimicrobial and protease-inhibitory activities. *Peptides*, *23*, 1–6.
143. Osusky, M., Zhou, G., Osuska, L., Hancock, R. E., Kay, W. W., Misra, S. (2000). Transgenic plants expressing cationic peptide chimeras exhibit broad-spectrum resistance to phytopathogens. *Nature Biotechnology*, *18*, 1162–1166.
144. McPhee, J. B., Scott, M. G., Hancock, R. E. W. (2005). Design of host defence peptides for antimicrobial and immunity enhancing activities. *Combinatorial Chemistry & High Throughput Screening*, *8*, 257–272.
145. Wiest, A., Grzegorski, D., Xu, B. W., Goulard, C., Rebuffat, S., Ebbole, D. J., Bodo, B., Kenerley, C. (2002). Identification of peptaibols from *Trichoderma virens* and cloning of a peptaibol synthetase. *The Journal of Biological Chemistry*, *277*, 20862–20868.
146. Freidinger, R. M. (2003). Design and synthesis of novel bioactive peptides and peptidomimetics. *Journal of Medicinal Chemistry*, *46*, 5553–5566.
147. Tam, J. P., Lu, Y. A., Yang, J. L. (2002). Antimicrobial dendrimeric peptides. *European Journal of Biochemistry*, *269*, 923–932.
148. Polcyn, P., Jurczak, M., Rajnisz, A., Solecka, J., Urbanczyk-Lipkowska, Z. (2009). Design of antimicrobially active small amphiphilic peptide dendrimers. *Molecules*, *14*, 3881–3905.