Table 30. Types of carbon-based nanoparticles as antimicrobial agent, their mechanisms of action and characteristics.

<table>
<thead>
<tr>
<th>Type of nanoparticles</th>
<th>Mechanism of antimicrobial action</th>
<th>Main characteristics as antimicrobial agent</th>
<th>Main factors that influence antimicrobial activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fullerene</td>
<td>Inhibit bacterial growth by impairing the respiratory chain; inhibition of energy metabolism.</td>
<td>Stability; Photodynamic therapy activity; high ability to functionalization; high surface/volume ratio; large inner volume</td>
<td>Particle size; type of functional group; surface charge.</td>
</tr>
<tr>
<td>SWCNTs</td>
<td>Physical interaction with cell membrane; formation of cell-CNTs aggregates; induction the cell membrane disruption.</td>
<td>Stability; high ability to functionalization; high surface/volume ratio; large inner volume</td>
<td>Particle size; particle length; type of functional group; type of buffer; concentration; surface charge.</td>
</tr>
<tr>
<td>Graphene oxide (GO)</td>
<td>Physical interaction with cell membrane; formation of cell-GO aggregates; induction the cell membrane disruption</td>
<td>Stability; high ability to functionalization, high surface/volume ratio; sharp edges of nanowalls.</td>
<td>Particle size; type of functional group.</td>
</tr>
</tbody>
</table>

Source: Future Markets, Inc.

5.9 CHITOSAN NANOPARTICLES

5.9.1 Properties

Chitosan nanoparticles (NPs) exhibit a wide range of antimicrobial activity against bacteria, filamentous fungi, yeast and even virus. The exact mechanism of antibacterial activity is yet to be fully understood. The most prevalent proposed antibacterial activity of chitosan is by binding to the negatively charged bacterial cell wall causing disruption of the cell thus altering the membrane permeability, followed by attachment to DNA causing inhibition of DNA replication and subsequently cell death.\(^{197}\) Another possible mechanism is that chitosan acts as a chelating agent that selectively binds to trace metal elements causing toxin production and inhibiting microbial growth.\(^{198}\)

Other properties that make it attractive for application in coatings include:

- Degradability
- solubility in weak acids
- pH-sensitivity
- film-forming property
- biocompatibility
- non-antigenic
- absence of toxicity