Supporting Information

# A Design Approach to Eliminate the Toxic Effect of Insecticides for Ensuring Human Safety

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**The document consists of 8 pages, 16 sections Supporting Information and 3 references.**

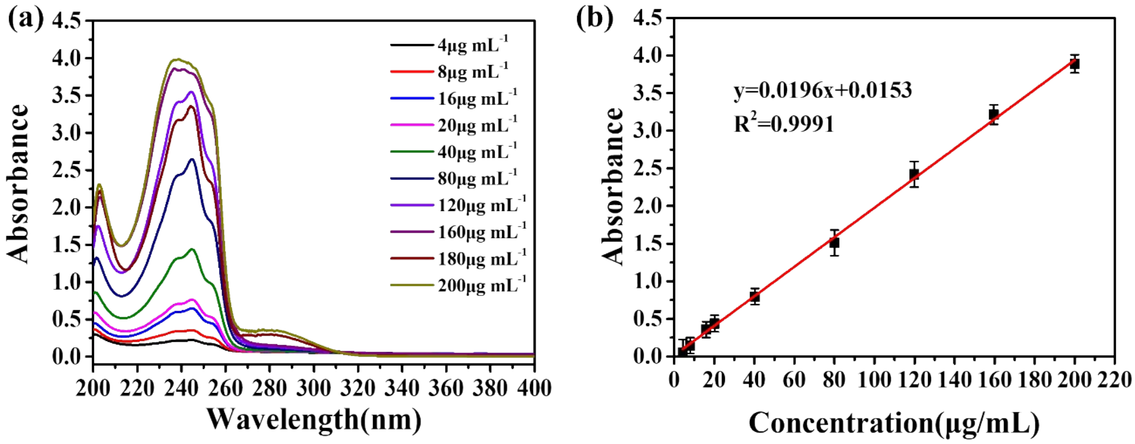


Figure.S1.Ultraviolet absorption spectrum (a) and standard curve (b) of AVM.

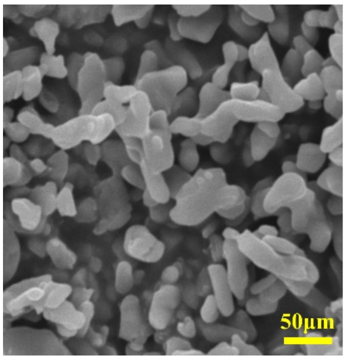


Figure S2. SEM image of RCM-PEGDA microspheres.

**S1 Cost assessment of the microspheres**

Table S1 The cost of the raw materials

| Materials | Cellulose | PEGDA | NaOH | Urea | TX-Ct | Others |
|---|---|---|---|---|---|---|
| Cost($/kg) | 3.17 | 2.06 | 0.4 | 0.17 | 6.34 | 0.1 |

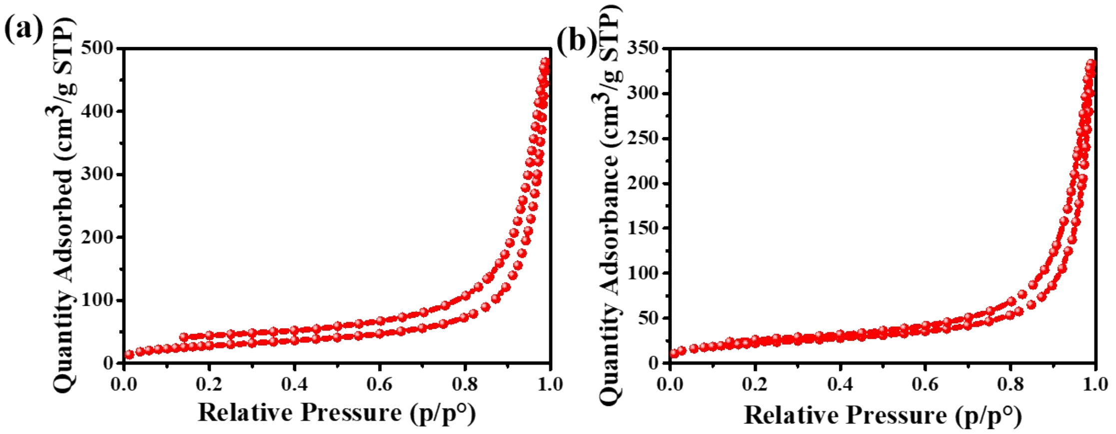


Figure.S3. $N_2$ adsorption-desorption isotherms of RCM (a) and RCM-PEGDA (b).

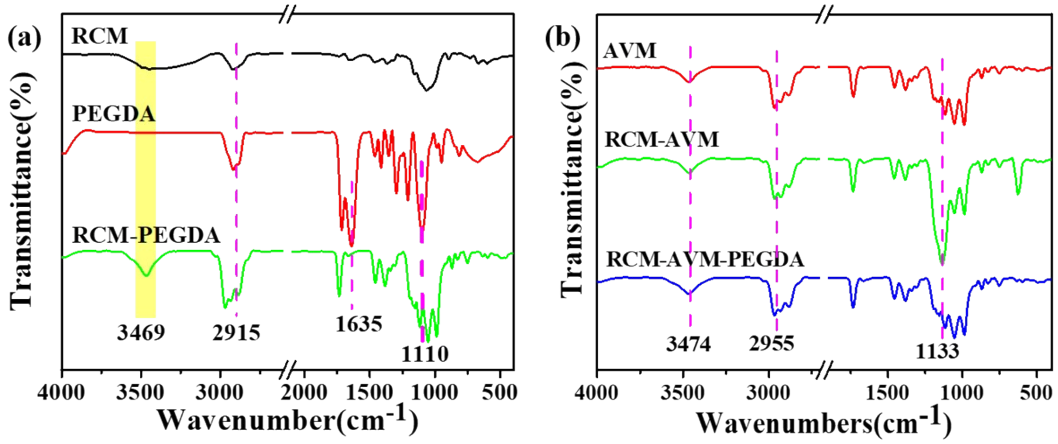


Figure.S4. FT-IR spectra of RCM, PEGDA and RCM-PEGDA (a), FT-IR spectra of AVM, RCM-AVM and RCM-AVM-PEGDA (b).

**S5 DI-loaded experiments**

The insecticide-loaded regenerated cellulose gel microspheres (RCM-DI-PEGDA) was prepared under the same conditions as described above, except that DI was added. The RCM was loaded with DI through a simple solvent adsorption method. First, 10 mg of the RCM was added to 10 mL of the DI solution at room temperature under stirring at 100 rpm. The DI-loaded RCM was termed RCM-DI. After shaking for 24 h, the supernatant was analyzed using a UV spectrophotometer. To evaluate the load of DI, 10 mg of DI was dissolved in a methanol solution; the concentration of the DI in the solutions was in the range of 4–200 μg $mL^{-1}$. At specific time intervals, a small portion of the solution was removed and analyzed by UV spectrophotometry at 270 nm. The calibration curve of DI was linear in the concentration range of 4–200 μg $mL^{-1}$. The regression equation was y = 0.01992x + 0.01997, and the correlation coefficient was $R^2$ = 0.9995. To demonstrate the strategy of loading the insecticide in the DI, a load of DI was analyzed using a standard calibration curve, and the DI loading capacity was calculated using the following formula[1]:

$$LC = \frac{(C_0 - C_t)V}{m_1}$$

where $LC$ (mg $g^{-1}$) is the load capacity of DI, $C_0$ (mg $L^{-1}$) is the initial concentration of DI, $C_t$ (mg $L^{-1}$) is the final concentration of DI, $V$ (L) is the volume of DI solution, $m_1$ (g) is the mass of RCM.

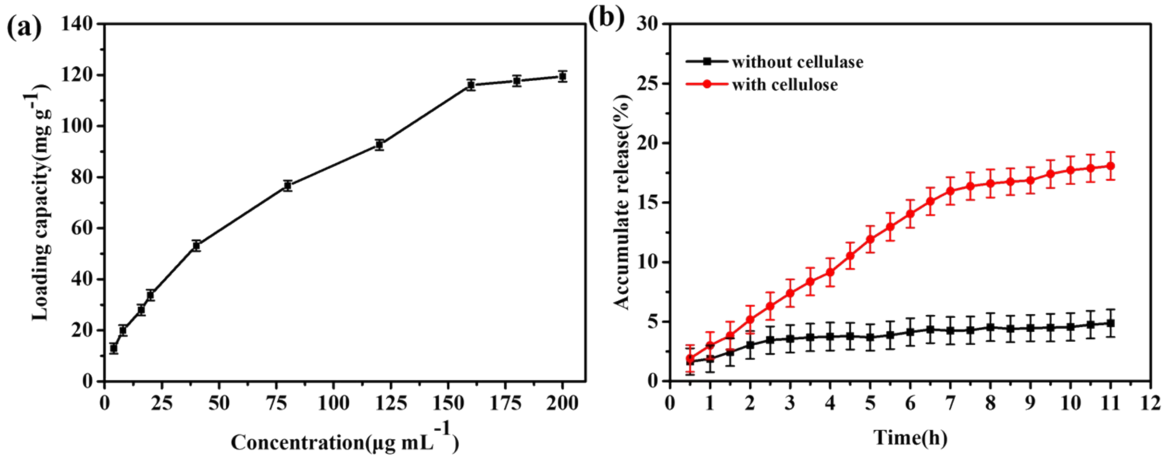


Figure. S5. The dependence of loading capacity on the DI concentration (a), the presence or absence of cellulase on the release behavior of RCM-DI-PEGDA (b).

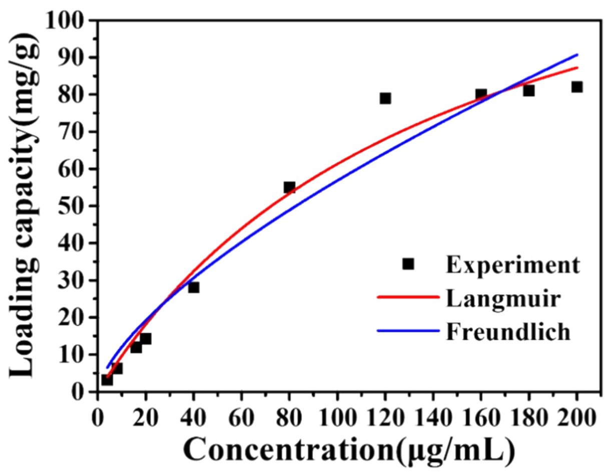


Figure.S6. Fitting of the RCM isotherm by the Langmuir and Freundlich equations.

Table.S2. Model and parameters of isotherms of RCM.

| Sample | *LC* (mg g$^{-1}$) | Langmuir | | | Freundlich | | |
|---|---|---|---|---|---|---|---|
| | | $q_m$ (mg g$^{-1}$) | $K_L$ (mL mg$^{-1}$) | $R_1^2$ | $K_F$ (mg g$^{-1}$) | 1/n | $R_2^2$ |
| RCM-AVM | 80.51 | 151.02 | 0.0068 | 0.979 | 2.55 | 0.6742 | 0.955 |

**S6 TGA and DTG Curves of Microspheres.**

The thermal stability of RCM-AVM and RCM-AVM-PEGDA of cellulose-based microspheres before and after insecticide loading is different from that of RCM, and TGA measurements were performed under $N_2$ atmosphere to study the thermal behavior. To inspect the thermal stability of RCM-AVM-PEGDA, Figure S5a, b shows the TGA and DTG thermograms of all the samples. The weight loss below 150°C may be due to the volatilization of steam, 4.64% of the total mass was lost[2]. The decomposition of AVM and RCM start at 241°C and 260°C, respectively. In the range of 220~320℃, it may be mainly due to the decomposition and evaporation of AVM. The main decomposition peak of RCM is at about 260°C-340°C, while the decomposition peak of RCM-AVM-PEGDA is about 300°C. This may be attributed to the weight loss due to the oxidative degradation of cellulose. Weightlessness is 65.13%. The small peak weight loss at about 520°C is the oxidative decomposition peak of residual carbon[3]. These results indicate that RCM-AVM-PEGDA has good thermal stability. In conclusion, PEGDA gel grafting effectively improves the thermal stability of RCM, which shows that the performance of insecticide formulations will not have a significant impact in a long time, and effectively improve the duration of insecticides.

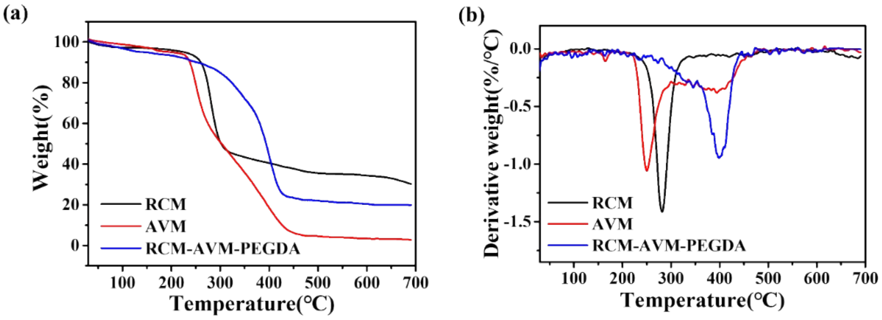


Figure.S7.TGA (a) and DTG (b) curves of RCM, AVM, RCM-AVM and RCM-AVM-PEGDA.

Table.S3. Dissipation Parameters of the AVM, AVM-EC and RCM-AVM-PEGDA microspheres.

| **Compound** | **UV irradiation** | | | |
|---|---|---|---|---|
| | *k*($h^{-1}$) | $R^2$ | $DT_{50}$(h) | $DT_{90}$(h) |
| **AVM** | 0.3176 | 0.9022 | 2.1825 | 7.2502 |
| **AVM-EC** | 0.0703 | 0.9664 | 9.8641 | 32.7677 |
| **RCM-AVM-PEGDA** | 0.0212 | 0.9998 | 32.7265 | 108.7151 |

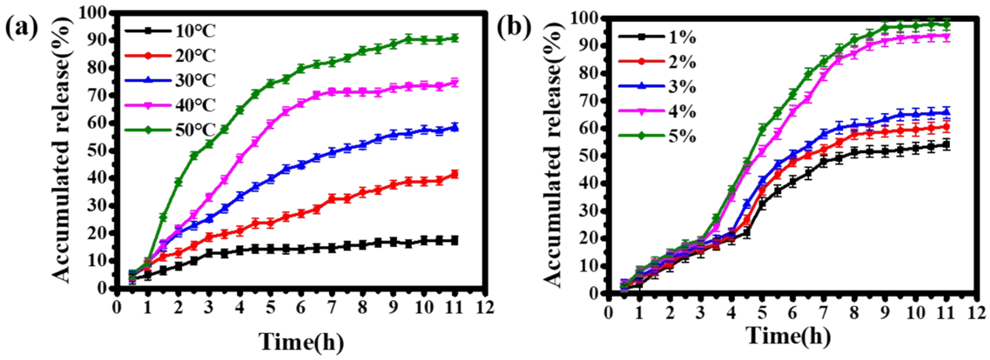


Figure.S8. (a) The release behavior of RCM-AVM-PEGDA at different temperatures (pH 7.0 and cellulase at 3%); (b)The release behavior of RCM-AVM-PEGDA under different cellulase concentrations (pH 7.0 and 37℃).

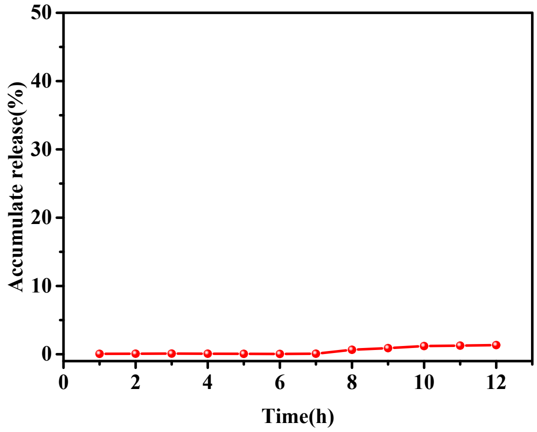


Figure S9. The release behavior of RCM-AVM-PEGDA under stomach conditions (pH 2.5 and 38℃).

Table.S4. Constants from fitting the generalized model, $M_t/M_\infty = Kt^n$, to the release data of AVM from RCM-AVM-PEGDA microspheres under different conditions.

| Conditions | | n | *K* (×10$^{-2}$) | $R^2$ |
|---|---|---|---|---|
| | 10 | 0.41 | 6.79 | 0.9174 |
| **Temperatures (℃)** | 20 | 0.66 | 8.46 | 0.9947 |
| | 30 | 0.64 | 13.34 | 0.9786 |
| | 40 | 0.63 | 18.54 | 0.9102 |
| | 50 | 0.53 | 28.09 | 0.9170 |
| | 1:1 | 0.96 | 9.56 | 0.9451 |
| **Cellulase amount** | 1:2 | 0.98 | 8.68 | 0.9509 |
| | 1:3 | 0.87 | 8.06 | 0.9355 |
| | 1:4 | 0.86 | 7.52 | 0.9361 |
| | 1:5 | 0.83 | 6.99 | 0.9437 |

Table.S5.MTT assay demonstrates the cytotoxicity of RCM-AVM-PEGDA microspheres in cell proliferation (* represents $P < 0.05$ by comparing with the blank group).

| | day1 | day3 | day5 |
|---|---|---|---|
| **RCM-AVM-PEGDA** | 0.30±0.02 | 0.70±0.01* | 1.02±0.08* |
| **RCM-AVM** | 0.30±0.01 | 0.64±0.02* | 0.94±0.08* |
| **AVM** | 0.29±0.01 | 0.57±0.03* | 0.80±0.04* |
| **Blank** | 0.30±0.01 | 0.79±0.01 | 1.12±0.05 |

**S7 Insecticidal activity analysis**

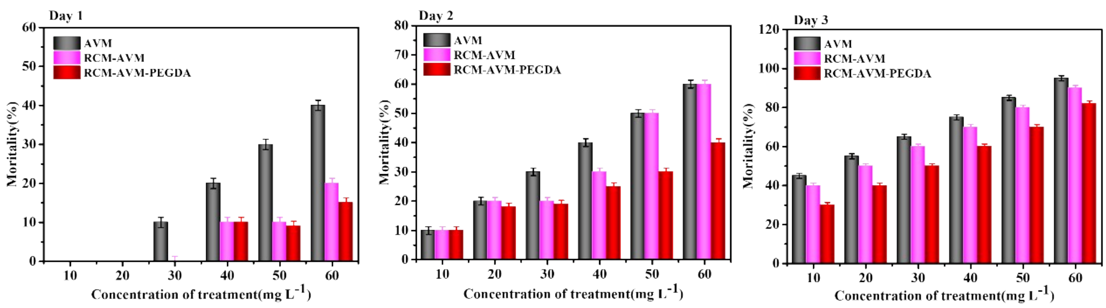


Fig S10. Mortality of different concentrations of AVM, RCM-AVM and RCM-AVM-PEGDA against *mole crickets*

Table S6 Toxicity of AVM, RCM-AVM, and RCM-AVM-PEGDA against *mole crickets*.

| Time after spraying(day) | | $LC_{50}$(mg $L^{-1}$) | $LC_{90}$(mg $L^{-1}$) | 95% Fiducial limit | Slope (mean± SE) | *P* | $\chi^2$ |
|---|---|---|---|---|---|---|---|
| **AVM** | Day1 | 0.669 | 1.373 | 0.764-7.437 | 1.702±0.016 | 0.990 | 0.290 |
| | Day2 | 0.502 | 2.199 | 0.520-3.475 | 0.754±0.008 | 0.996 | 0.173 |
| | Day3 | 0.172 | 0.931 | 0.449-3.047 | 0.663±0.008 | 0.929 | 0.867 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **RCM-AVM** | Day1 | 0.911 | 1.758 | 1.126-10.101 | 2.869±0.117 | 0.961 | 0.620 |
| | Day2 | 0.565 | 2.502 | 0.475-3.493 | 0.770±0.010 | 0.877 | 1.208 |
| | Day3 | 0.172 | 0.931 | 0.449-3.049 | 0.663±0.008 | 0.929 | 0.867 |
| **RCM-AVM-PEGDA** | Day1 | 1.112 | 2.516 | 1.554-8.851 | 2.654±0.169 | 0.948 | 0.729 |
| | Day2 | 1.234 | 13.633 | 0.256-2.712 | 0.7570±0.105 | 0.993 | 0.246 |
| | Day3 | 0.248 | 1.385 | 0.424-3.001 | 0.659±0.009 | 0.953 | 0.684 |

**References**


1.M. Zhao, H. Zhou, L. Hao, H. Chen and X. Zhou, *Carbohydrate Polymers* 2021, ***259***, 117749.

2. A.M.A. Nada, M. L. Hassan, *Polymer Degradation and Stability* 1999, ***67***, 111-115.

3.S. Ouajai and R. A. Shanks, *Polymer Degradation and Stability* 2005, ***89***, 327-335.