Mating Disruption/SIR

Effects of sunlight on encapsulated sprayable codling moth pheromone

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Abstract: The ultraviolet protective qualities of several formulations of encapsulated sprayable codling moth pheromone were compared qualitatively using high intensity UV light in a sealed chamber. The most effective formulation was quantitatively evaluated using sunlight (visible and UV) in simulated field conditions over time. The most effective formulation proved to be Suterra's current registered formulation. Results indicate that the current Suterra sprayable formulation prevents codlemone degradation in the shade and significantly reduces degradation in direct sunlight over 30 days.

Introduction

Codling moth (*Cydia pomonella*) pheromone ((E,E)-8,10 Dodecadien-1-ol) is known to degrade significantly when exposed to UV and visible light. Suterra's codling moth flowable (CM-F) product is marketed as a 30-day product. Therefore, a formulation that will protect the pheromone from UV degradation for at least 30 days must be developed. By producing several mini-batches of sprayable with various UV stabilizers we are able to test the efficacy of our current formulation against other possible formulations as well as the competition. Once the most effective formulation is identified we can test it further using real sunlight to get an idea of how it might behave in the field. Ultimately, this will allow us to assess the current registered formulation and decide whether or not a change in formulation is necessary.

Materials and Methods

Eight CM-F mini-batches were made using eight different UV stabilizing formulations including Suterra's currently registered formulation. These batches were tested along with a sample of the competitor's registered formulation. Each formulation was tested in triplicate. For each test three filter papers were dried in a 40°C oven for 1 hour and their tare weights recorded. Each sample was loaded onto the filter papers and placed into a 40°C environmental chamber to evaporate water. The net weights of the papers were recorded, and the papers were placed in sealed UV/Visible cuvettes.

The cuvettes were placed randomly in a 19x19x25 cm box fitted with a UV light and lined with aluminum foil (shiny side facing the light). The box was sealed and the samples were irradiated for 5 days at a wavelength setting of 365 nm. Extraction of the samples and subsequent GC analysis were performed.

Simulated field conditions were obtained by placing samples loaded according to the protocol above outside in areas of full sun and shade. The control consisted of a sample set that was placed in a cupboard for the duration of the test (dark sample). The test was repeated over nine time points: 5 h, 1, 2, 7, 10, 15, 20, 25 and 30 days. The test formulation was run against an unstabilized formulation (encapsulated codlemone without the UV stabilizing component) and unstabilized neet codlemone pheromone as controls at each time point. At the end of each time point the samples were extracted and analyzed according the protocol stated above.

Release rate studies were performed according to a SOP established for quality assurance. Each test was performed in sets of four replicates with one control. Diluted samples were loaded onto filter discs with tare weights recorded. The discs were dried a second time and placed in a 40°C environmental chamber for 28 days along with a control disc loaded with only water. The weight loss percentages for the samples were recorded and adjusted according to the control on days 1, 3 or 5, 7, 14, 21 and 28.

Results and Discussion

Initial testing of the sprayable mini-batches indicated that the most effective formulations were Formulations 1 and 7. Fig. 1 shows the percent active pheromone remaining for each sample. From this figure it is evident that Formulations 1 and 7 provided more UV protection in the sealed cuvettes than any other formulation. Formulations 1 and 7 appear to contain approximately 100% of the original pheromone encapsulated, within their respective error. Formulations 2 and 3 also showed considerable protection. This was significant given that Formulations 2 and 3 contained varying amounts of the same stabilizer as Formulation 1, confirming that their stabilizing components effectively protect against UV degradation. Conversely, Formulations 6, 8 and 9 provided little UV protection.

The release rate trends for the various formulations (see Fig. 2) were important as indicators of sprayable longevity in the field. All of the formulations exhibited an initial burst of pheromone release. The magnitude of this initial burst, or the slope in each plot, dictates the length of overall effective pheromone release for each formulation. From this figure it can be seen that Formulation 1 with a slope of 3.3 and a weight loss of 43.4% over 21 days has the slowest release rate of the mini-batches. Conversely, Formulation 7 with the steepest slope, 12.5 and an overall release of 72.5 percent by day 7, has the fastest release of the mini-batches. These data suggest that Formulation 7 would not last as long in the field compared to Formulation 1. It is possible that while the stabilizer in Formulation 7 adequately protects against UV degradation, it compromises the integrity of the microcapsule wall. This release rate comparison further confirms Formulation 1 as the best formulation for UV protection and theoretical field performance. The slowest release rate overall was observed for Formulation 9 which released 0.59 weight percent over 21 days.

Once Formulation 1 was determined to be an effective formulation for decreasing pheromone degradation it was tested in simulated field conditions in order to assess "real" pheromone degradation due to sunlight. The direct sunlight results are shown in Figure 3. Neet pheromone appears to be completely degraded by day 2 and the unstabilized CM-F decreased below 40% by day 7. The stabilized formulation maintained better than 70% integrity but dropped below 50% by day 30 in the full sun. Although both the stabilized and unstabilized formulations did show degradation, the stabilized formulation did retain almost twice the active pheromone as the unstabilized. This suggests that, while the microcapsule itself may provide some protection against degradation, the added stabilizer increases the protection almost 100%.

The diffuse and reflected light results for Formulation 1 indicate that, in the shade, Formulation 1 protects codlemone almost 100% from degradation (see Fig. 4). In diffuse light conditions the stabilized formulation retained almost all of its encapsulated pheromone compared to the unstabilized which retained 60% over 30 days' light exposure. Even though the full sun results showed degradation, shade results confirmed Formulation 1 as an effective formulation. Considering the raw pheromone, this degrades completely by the end of the 30-day test while the stabilized formulation maintains an average of 98% active pheromone for the duration of the test. The unstabilized formulation maintains over 95% active pheromone for 7 days, but the pheromone levels drop to near 50% at the end of the test. These results are significant considering field conditions expose microcapsules to mostly diffuse and reflected light. When sprayable is applied from the ground using an airblast sprayer, a high percentage of the microcapsules adhere to the underside of leaves and branches, providing ample shade to reduce full sun exposure.

The dark results acted as an effective control for the tests performed in the full sun and shade (see Fig. 6). The stabilized and unstabilized formulations behaved similarly retaining almost 100 percent active pheromone. The neet pheromone showed no recognizable pattern of degradation suggesting that any pheromone loss was due to slight evaporation, not degradation. These results indicate that pheromone loss in the tests performed was due to significant degradation as a direct result of exposure to sunlight.

Simulated field tests were performed during the months of July and August. In order to test the effects of light (UV and visible) exposure to the test samples, the total UV radiation for the duration of the test was compared to the cooling degree-days (see Fig. 6). Cooling degree-days are defined as the average temperature for the day (°C) minus 18.6°C and relate the amount of energy that would be needed to cool a room on a given day. In the figure, it is evident that UV exposure is independent from the cooling degree-day index for the duration tested, further suggesting that degradation was related to light exposure, not heat.

As a result of these of tests, Formulation 1, Suterra's registered Codling Moth Flowable, was determined to be the best formulation for UV protection of codlemone. This formulation's performance in the shade was exemplary, confirming its effectiveness as a 30-day product when it is applied so that it is not exposed to direct sunlight. More formulations must be tested in order to improve protection against degradation from direct sunlight if the sprayable application mode is changed.

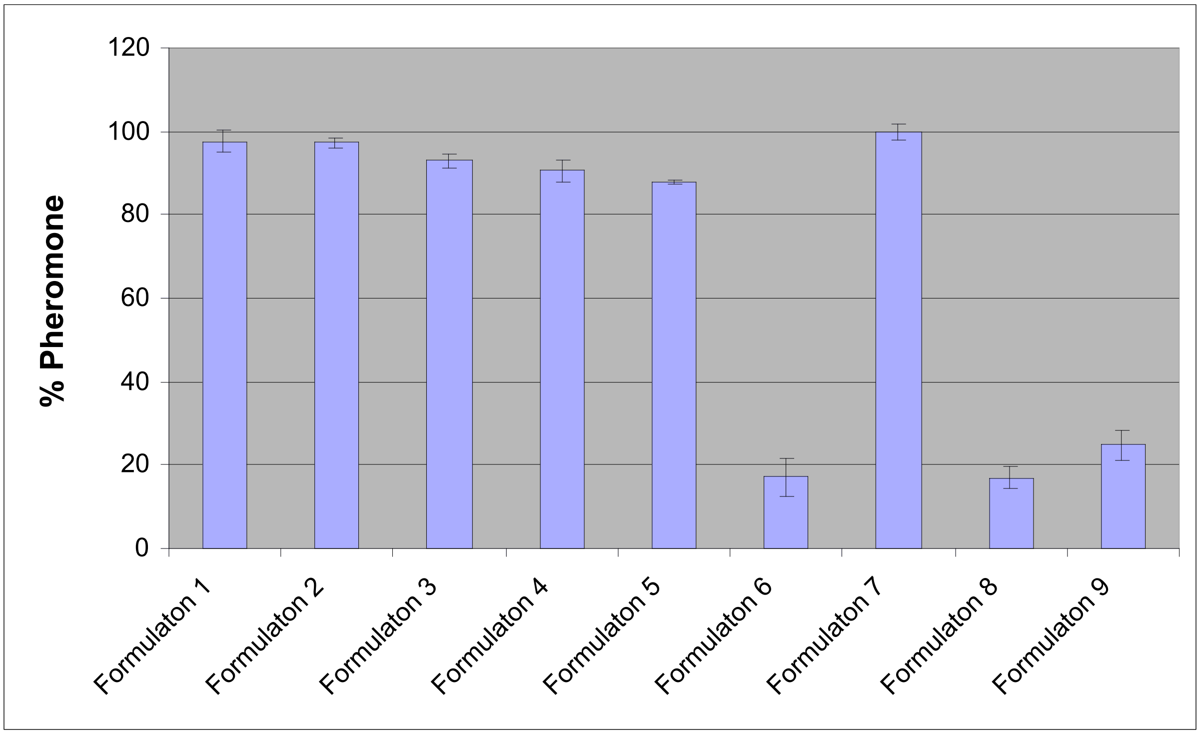

Fig. 1. Percent pheromone remaining after 5 days exposure to UV (365nm) radiation.

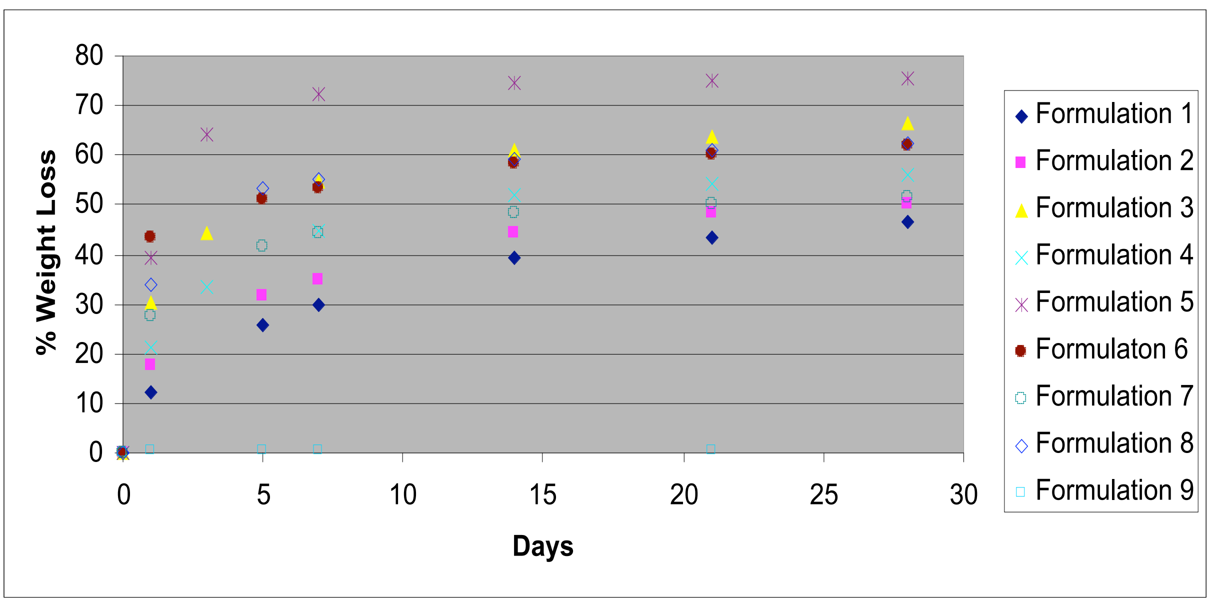

Fig. 2. Mini-batch release rate comparison including a sample of the competitors formulation.

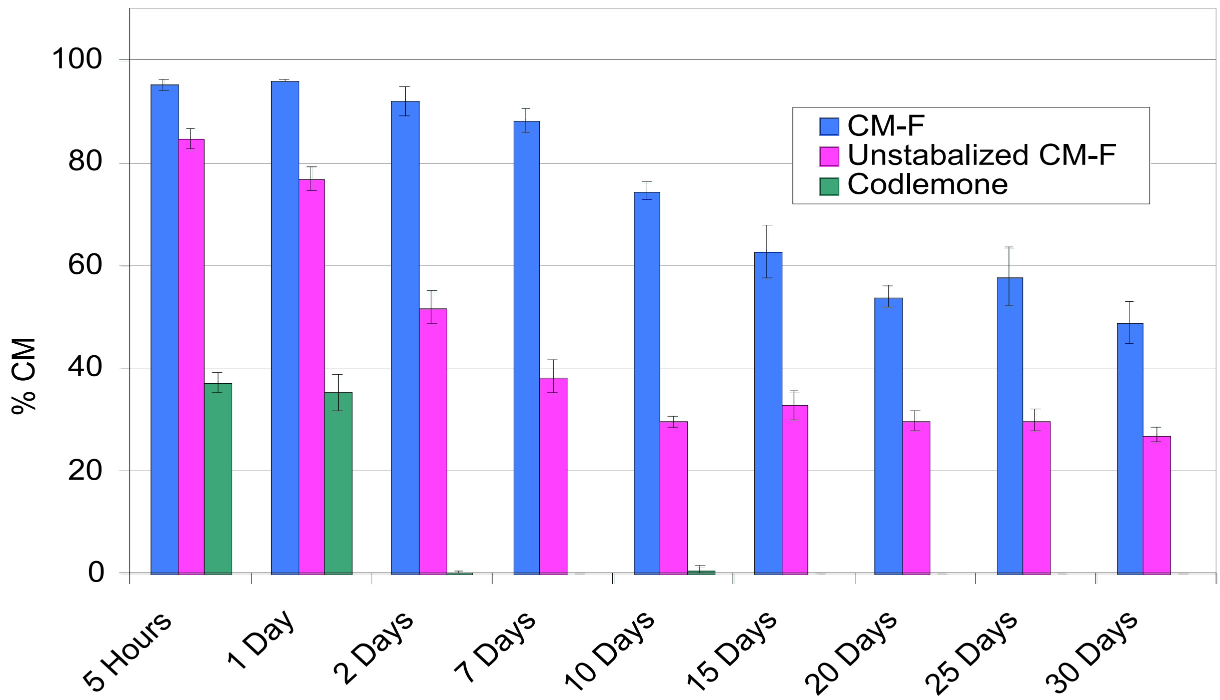

Fig. 3. Degradation by direct sunlight of stabilized flowable, using Suterra's current registered formulation, as compared to unstabilized product as well as raw pheromone with Standard Error Bars (% codlemone).

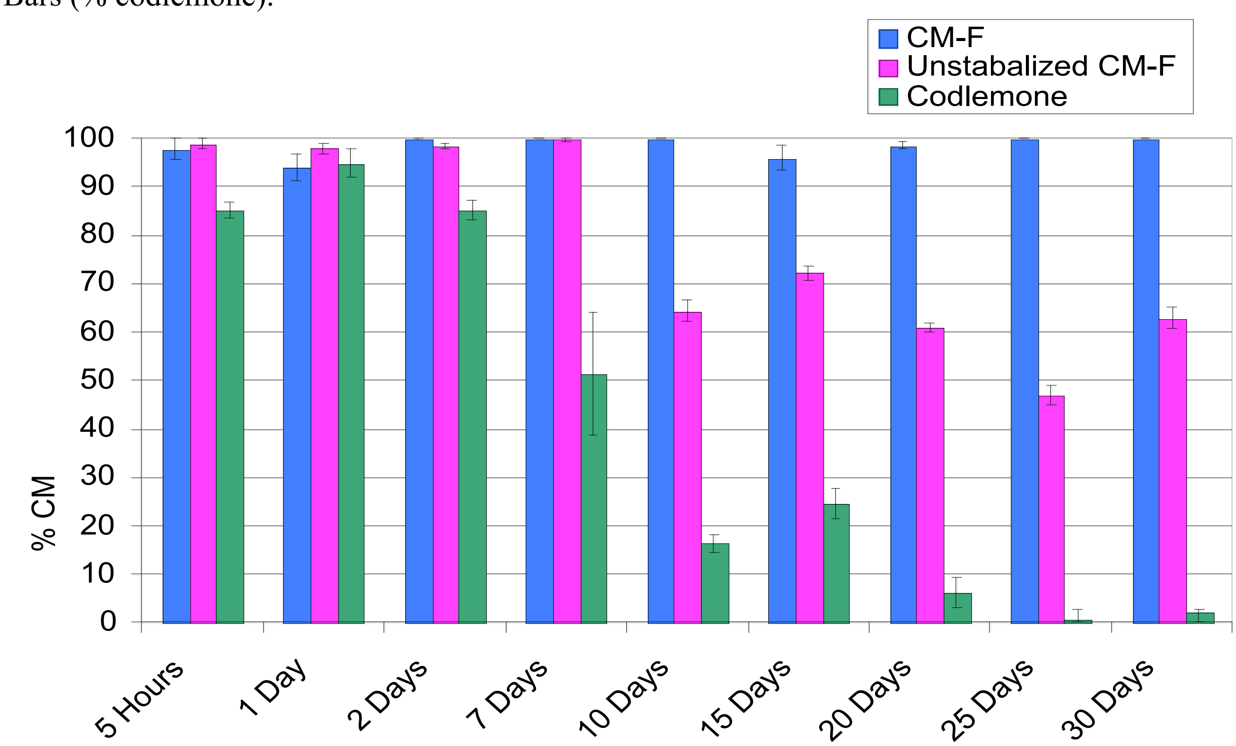

Fig. 4. Degradation in diffuse (shade) conditions with Standard Error Bars (% codlemone).

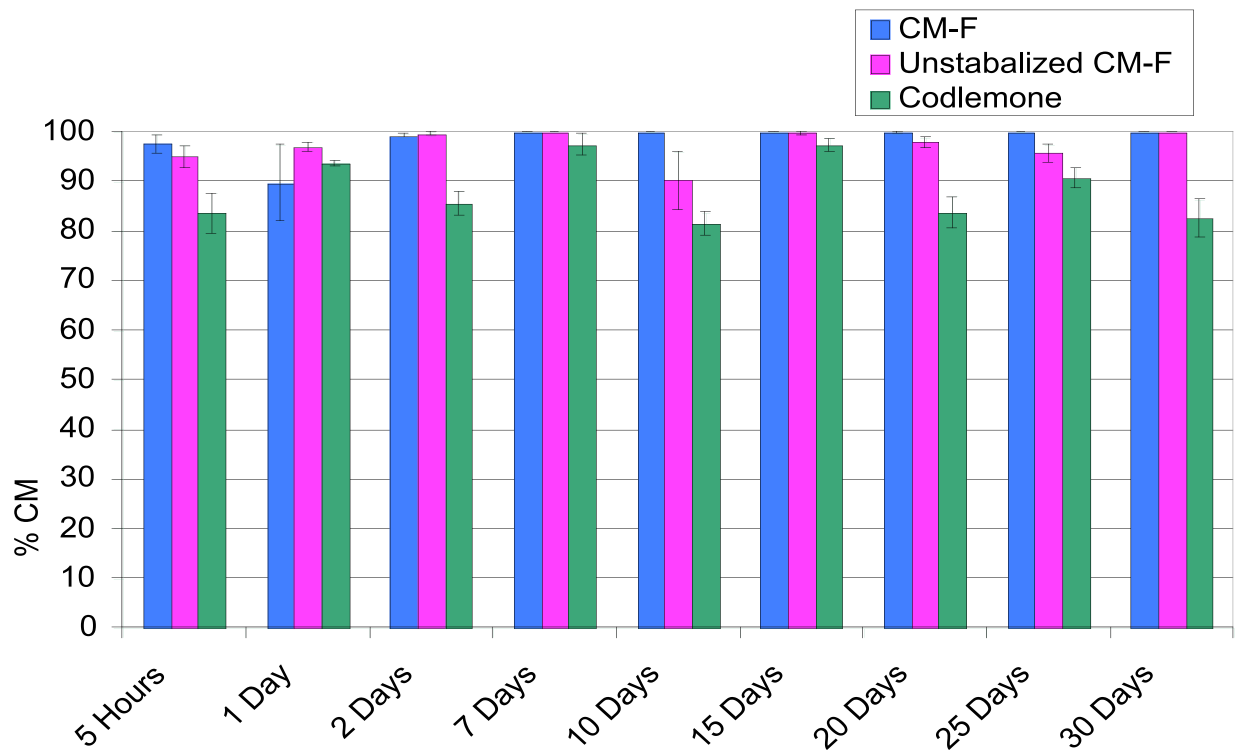

Fig. 5. Control Results, data recorded in the absence of light with Standard Error Bars (% codlemone).

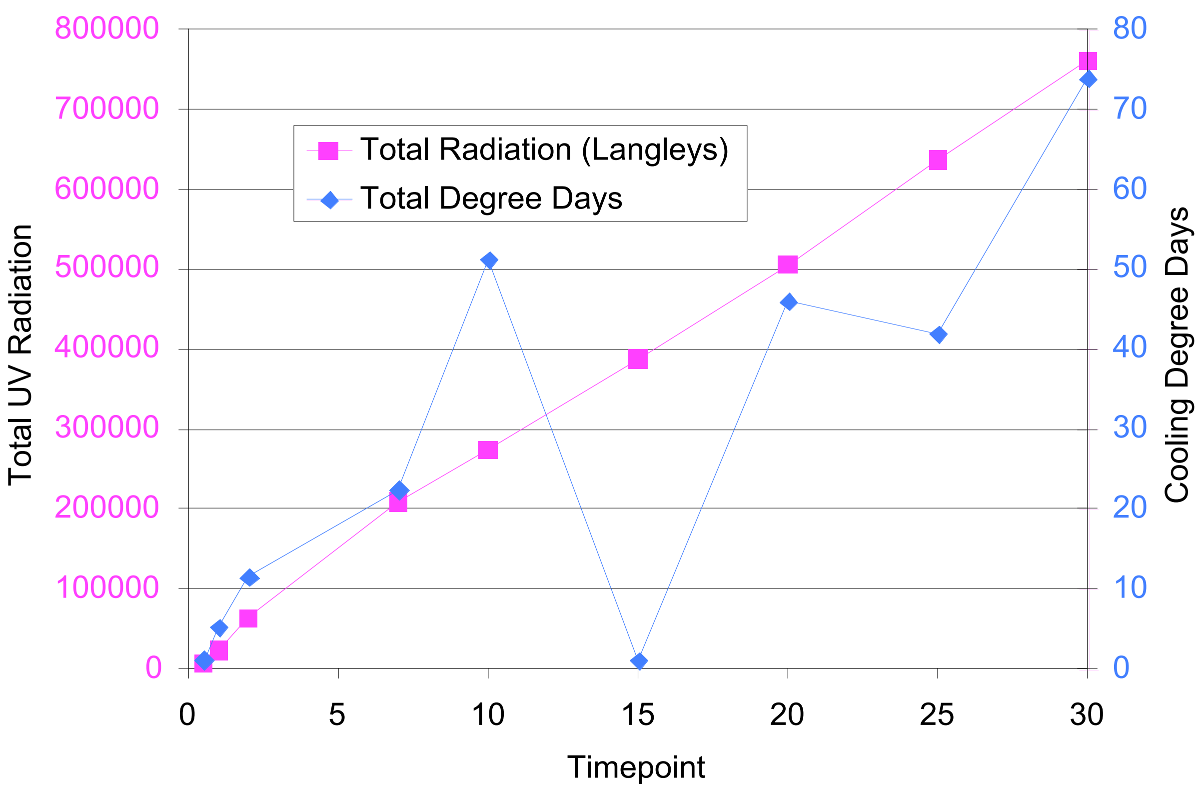

Fig. 6. Cooling Degree Days and Total UV Radiation (Langleys).

References

University of Oregon Solar Radiation Monitoring Laboratory. 2002. http://solardat.uoregon.edu/SolarData.html, December 5, 2002