The Pharma Innovation Journal 2023; 12(4): 1923-1925

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 1923-1925

www.thepharmajournal.com
Received: 15-02-2023
Accepted: 18-03-2023

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# A novel approach to amalgamate zeolites 4A with Carbopol 940 aqueous gel formulation for slow, sustained, and extended release of Z-9-tricosene in open fields

**S Kannan, Lokesh Makam and SP Venkatesh Prasad**

**Abstract**
Various formulations were prepared and evaluated for sustained release of Z-9-tricosene in open fields. Of all the formulations evaluated pH stabilised Carbopol 940 gel exhibited reasonable slow and sustained release of Z-9-tricosene for a good period but with high daily release potential. Activated zeolites 4A sorbed with the stabilised Z-9-tricosene formulation, exhibited a quick release, also with high daily release potential. A novel approach was developed to combine the pH modulated Carbopol 940 gel with the zeolites 4A, both charged with Z-9-tricosene formulation entrapped into the aqueous gel of Carbopol 940 and porous channels of the aluminosilicates of zeolites 4A. This newly developed formulation is eco-friendly, safe, and biodegradable and demonstrated slow, sustained, and extended release with an average release of 65.28±0.08 mgs of Z-9-tricosene, effectively for 15days with 1gm of loading dose.

**Keywords:** Z-9-tricosene, carbopol-940 gel, zeolites

## 1. Introduction

Sustained release formulations can be prepared, generally using various organic matrices including treated cellulose like methyl cellulose, carboxy methyl cellulose, hydroxy propyl methyl cellulose, gelatine, and others. These formulations are generally prepared for sustained release of drugs for few hours and are internally consumed by humans and animals. Preparation of sustained release pheromone formulations with sustained release effect for number of days is a big challenge, because the formulation must be placed in an open area and must demonstrate the sustained release of pheromones into the surrounding atmosphere for a desired period, sometimes for more than one or two weeks.

Need of the hour is to effectively control the economically important agricultural pests without harming nature, health of farmers and health of society. Today many of the pests have developed resistance to man-made unnatural chemicals. It's globally evident that these man-made chemicals are not only harming the nature but also inducing the chemical mediated genotoxicity and causing diseases like cancer and functionally disruptive endocrine diseases.

Monitoring, trapping, and controlling of pests using pheromone-based products in the agriculture fields gaining importance, as these pheromones are biomolecules and are naturally produced by the pests to communicate among the pests of the same group. Attempts were made to formulate and evaluate sustained release pheromone formulations to support farmers to monitor, trap and control pests with ease and without tedious work by the farmers also to reduce the presence of pesticidal residues in the agricultural produce and to decrease the preharvest loss and to increase the yield.

Considering the challenges, we have attempted to develop a novel eco-friendly, safe, and biodegradable formulation for the slow and extended release of Z-9-tricosene in open fields.

Zeolites are naturally occurring solid, crystalline aluminosilicates, unique porous materials with 3D framework of cavities and channels. These channels allow the drift of resident ions and molecules into and out of the structures, assimilating the small molecules to reside [9-11]. Since they are referred to as molecular sieves, used in wide variety of applications [2]. Presently 40 natural and synthetic zeolites with 191 distinctive frameworks identified [1].

The aluminosilicates framework is negatively charged and attracts positive cations or molecules with bipolarity that reside in the channels to compensate the negative charge of the aluminosilicate framework [3].

The unique properties zeolites, as porous materials depend both on the pore structures and the chemistry of the framework in both natural and synthetic or chemically modified zeolites. Continuously increasing demands for these porous zeolite materials with highly specific chemical and physical properties have inspired scientists to make newer porous materials with unique structures [4-8].

Carbopol polymers are high molecular weight, cross linked, acrylic acid-based polymer. These are polymers of acrylic acid cross-linked with poly-alkenyl ethers or divinyl glycol. The Carbopol polymer family is based on cross linked acrylic acid chemistry. The products are cross linked at various levels providing a portfolio of functionally diverse performance options. Carbopol polymers are efficient and effective rheology modifiers [12-14].

Carbomer readily absorb water, get hydrated and swell. Carbopol polymers are bearing particularly good water sorption property. In addition to its hydrophilic nature, its cross-linked structure and its essentially insolubility in water makes Carbopol a potential candidate for use in controlled release drug delivery system [13].

The three-dimensional nature of these polymers confers some unique characteristics, such as biological inertness, not found in similar linear polymers. The Carbopol resins are hydrophilic substances that are not soluble in water. Rather, these polymers swell when dispersed in water forming a colloidal, mucilage-like dispersion [15].

## 2. Materials and Method

Indigenously produced Z-9-tricosene of 95% purity, was procured from in-house Advanced Pheromone development (APD) dept., Barrix Agro Sciences, Molsieve-13X, Molecular Sieve Zeolites of 2-4mm (Zeolites 4A), the specific variant was obtained from Gujarat Multi Gas Base Chemicals Pvt Ltd., Carbopol-940 was purchased from s d fine-chem limited. All the other chemicals and reagents used in the formulation development and its evaluation were of analytical grade.

### 2.1 Preparation of Z-9-tricosene dispersed Carbopol 940 gel

100 ml Purified water made alkaline with potassium citrate was slowly incorporated into the 2 gms of polyacrylate 940 (Carbopol 940) with continuous stirring, allowed to stand for 30min to complete gelation. 5gms of glycerol, moisture retaining agent was added with continuous stirring to ensure uniform mixing. To the resultant gel 0.002% Butylated Hydroxy Toluene (BHT) and 1%Para-Amino Benzoic Acid were added with constant stirring to stabilise the gel. Finally, 1gm of Z-9-tricosene was slowly incorporated into the gel with constant stirring. The pH of the resultant gel was adjusted to 6.5 using triethanolamine. The gel was stirred for 30min to ensure the uniform dispersion of Z-9-tricosene.

### 2.2 Preparation of Z-9-tricosene sorbed Zeolites 4A.

The Zeolites 4A was activated by heating the Zeolites 4A in the hot air oven at $110^0$ for 30min.

To 1gms of Z-9-tricosene, 0.002% Butylated Hydroxy Toluene (BHT) and 1% Para-Amino Benzoic Acid were added with constant stirring to obtain stabilised Z-9-tricosene formulation. The stabilised Z-9-tricosene formulation was slowly added to 2gms of activated Zeolite 4A, and allowed for complete sorption, ensuring the incorporation of Z-9-tricosene into the molecular sieves of the Zeolite 4A.

### 2.3 Preparation of Angstrom void polymer gel (AVP Gel) matrix of Z-9-tricosene in the ratio of 1:4 (Carbopol 940 gel: Zeolites 4A)

#### 2.3.1 Preparation of Z-9-tricosene dispersed Carbopol 940 gel

100 ml Purified water made alkaline with potassium citrate was slowly incorporated into the 2 gms of polyacrylate 940 (Carbopol 940) with continuous stirring and allowed to stand for 30 min to complete the gelation. 5 gms of glycerol, moisture retaining agent was added with continuous stirring to ensure uniform mixing. To the resultant gel 0.002% Butylated Hydroxy Toluene (BHT) and 1% Para-Amino Benzoic Acid were added with constant stirring to stabilise the gel. Finally, 0.2gms of Z-9-tricosene was slowly incorporated into the gel with constant stirring. The pH of the resultant gel was adjusted to 6.5 using triethanolamine. The gel was stirred for 30min to ensure the uniform dispersion of Z-9-tricosene.

#### 2.2.2 Preparation of Z-9-tricosene sorbed Zeolites 4A

The Zeolites 4A was activated by heating the Zeolites 4A in the hot air oven at $110^0$ for 30 min.

To 0.8 gms of Z-9-tricosene, 0.002% Butylated Hydroxy Toluene (BHT) and 1% Para-Amino Benzoic Acid were added with constant stirring to obtain stabilised Z-9-tricosene formulation. The stabilised Z-9-tricosene formulation was slowly added to 2gms of activated Zeolite 4A, and allowed for complete sorption, ensuring the incorporation of Z-9-tricosene into the molecular sieves of the Zeolite 4A.

#### 2.2.3 Preparation of Angstrom void polymer gel (AVP Gel) matrix

The Z-9-tricosene charged Zeolites 4A prepared in the step 2 was dispersed into the Z-9-tricosene charged Carbopol 940 gel prepared in the step 1. The mixture was slowly stirred to ensure the uniform dispersion of charged Zeolites and to obtain Z-9-tricosene charged Angstrom void polymer gel (AVP Gel) matrix.

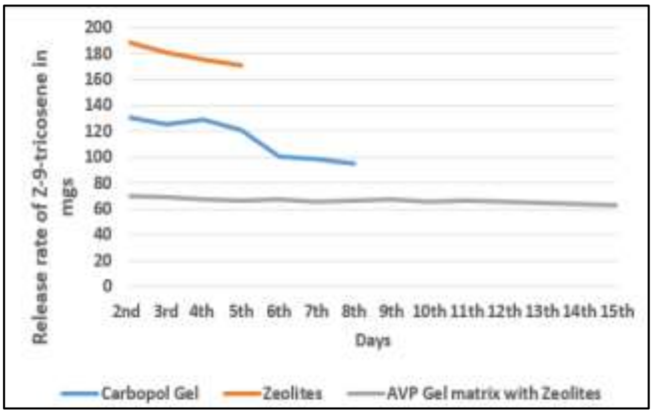


**Fig 1:** Comparative and sustained release rates of Z-9-tricosene from Carbopol 940 Gel formulation, Zeolites 4A charged with Z-9-tricosene and Z-9-tricosene charged Zeolites 4A dispersed in Z-9-tricosene charged Carbopol 940 gel (AVP Gel matrix).

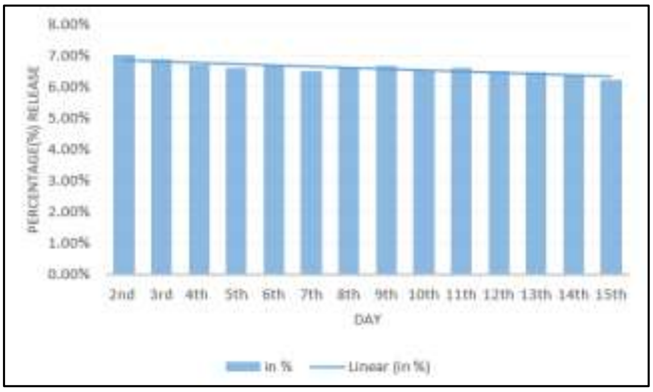


**Fig 2:** Percentage (%) release of Z-9-tricosene from Zeolites dispersed AVP Gel matrix.

## 3. Results and Discussion

After initial assessment, Zeolites 4A pellets were chosen considering the pellets size, Al/Si ratio, pore dimensions and its framework.

Carbopol 940 gel showed an average release of 116.69±0.18 mgs Z-9-tricosene. The pH stabilised Carbopol 940 gel exhibited and sustained its release pattern for a period of 08 days when deployed in outdoor, open field evaluation. But the average daily release potential was high. Whereas activated zeolites 4A having a molecular sieves of the size $4A^0$ units were able to extend the release rates to a maximum of 05 days, with a very high daily release potential. Individually both the formulations failed to meet the desired sustained release effect.

When activated Zeolites 4A and Carbopol 940 gel are combined, where both are charged with the variable amounts of Z-9-tricosene, exhibited a good, sustained release of Z-9-tricosene. Number of experiments were conducted to optimise the quantity of Z-9-tricosene in both activated Zeolites 4A and Carbopol 940 gel to ensure the prolonged and constant release of Z-9-tricosene. It was concluded that when the Z-9-tricosene was charged at a ratio of 1:4 into Carbopol 940 gel and activated Zeolites 4A, the resultant Zeolites 4A dispersed Carbopol 940 gel demonstrated a good sustained and constant release of Z-9-tricosene, effectively for 15 days with an average release rate of 65.28±0.08 mgs, with a loading dose of 1gm of Z-9-tricosene.

It was established that, when the surface Z-9-tricosene molecules gets diffused into the flowing atmospheric air in the open fields, the Z-9-tricosene, held by the ionic interactive forces by the aluminosilicates in the molecular sieves of the Zeolites 4A moves out of the sieves to maintain the concentration gradient of Z-9-tricosene with in the pH stabilised Carbopol 940 gel. This in and out movement of Z-9-tricosene from the molecular sieves of the Aluminosilicates of the microporous and mesoporous Zeolites 4A, plays an important role in the sustained release of Z-9-tricosene from the newly developed novel, eco-friendly, safe, and biodegradable angstrom void polymer (AVP) gel formulation (patent applied).

## 4. Conclusion

The present experimental studies and results obtained, it was concluded that quantity of moisture retaining agent i.e., glycerol added and final pH of the organic Carbopol 940gel, ratio of Al/Si and the size of the molecular sieves present in the Zeolites 4A plays an important role in the control and sustained release of Z-9-tricosene.

## 5. Acknowledgement

Authors sincerely thank Shri. Lokesh Makam, CEO and management of M/s. Barrix Agro sciences pvt ltd for creating and providing us all the necessary facilities to carryout research activities.

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