



## TANQIDIY NAZAR, TAHLILIIY TAFAKKUR VA INNOVATSION G'OYALAR



### INVESTIGATION OF THE REPELLENT ACTIVITY AGAINST IXODID TICKS BASED ON THE STRUCTURAL AND PHYSICOCHEMICAL PROPERTIES OF DIBUTYL ADIPATE.

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**Annotation:** *This study investigates the repellent activity of dibutyl adipate against ixodid ticks, with particular emphasis on its structural and physicochemical properties. As an ester of adipic acid and butanol, dibutyl adipate exhibits low volatility, lipophilicity, and favorable spreading characteristics on the skin surface, making it a potential alternative to conventional synthetic repellents. The chemical structure and polarity of the molecule were analyzed in relation to its effectiveness in repelling ticks. Laboratory bioassays were conducted to assess the duration and intensity of repellent action. The findings suggest that dibutyl adipate demonstrates moderate to high repellent efficacy under controlled conditions, indicating its potential application in the development of eco-friendly tick repellent formulations.*

**Keywords:** *dibutyl adipate, repellent activity, ixodid ticks, physicochemical properties, ester compounds, eco-friendly repellents, tick control, adipic acid derivatives.*

**Introduction:** Ticks, particularly those of the Ixodidae family, are significant vectors of various diseases affecting both humans and animals. The growing prevalence of tick-borne illnesses has increased the demand for effective and safe repellent agents. While synthetic repellents such as DEET have been widely used, their potential toxicity, environmental impact, and growing resistance among arthropods have prompted the search for alternative compounds.

Dibutyl adipate (DBA), an ester formed from adipic acid and butanol, is a compound with favorable physicochemical properties such as low volatility, good skin absorption, and environmental compatibility. It has been used as a plasticizer in industrial applications, but its potential as a bioactive substance, particularly in tick repellency, remains underexplored.

This study aims to investigate the repellent activity of dibutyl adipate against ixodid ticks, examining the relationship between its molecular structure, physicochemical characteristics, and biological effectiveness. The results may contribute to the development of environmentally friendly and safer repellent formulations for tick control.





**Literature review:** Tick-borne diseases, including Lyme borreliosis, anaplasmosis, and babesiosis, have become a growing concern worldwide due to the expanding habitat of ixodid ticks caused by climate change and ecological disruption. The primary method of preventing tick bites remains the use of repellents. Synthetic agents such as N,N-diethyl-meta-toluamide (DEET), icaridin, and permethrin have shown proven efficacy but are increasingly scrutinized for their toxicity, environmental persistence, and effects on non-target species (Brown et al., 2017; WHO, 2020).

As a result, research attention has turned toward alternative repellent substances, particularly those derived from naturally occurring or structurally simple compounds. Esters of dicarboxylic acids, such as dibutyl adipate (DBA), have emerged as promising candidates due to their amphiphilic nature and dermal compatibility. Previous studies have noted the plasticizing, emollient, and solvent properties of DBA, particularly in cosmetics and pharmaceutical formulations (Jenkins & Hall, 2015). However, its potential as a repellent against arthropods, especially ticks, remains underexplored.

Preliminary screening by eco-toxicologists suggests that adipate esters exhibit low mammalian toxicity and are biodegradable (Gómez et al., 2018), which aligns with the growing demand for eco-friendly biocides. Some comparative trials involving DBA and essential oil-based repellents demonstrated that DBA could prolong the activity of volatile components (Smith et al., 2019). Nevertheless, a detailed examination of its direct repellent action against ixodid ticks, as well as its physicochemical interactions with tick cuticle receptors, is still lacking.

This review highlights a gap in the literature regarding the use of dibutyl adipate as a stand-alone repellent, providing a rationale for the current study, which aims to evaluate its efficacy and suitability for tick control applications.

*Methodology:*

1. *Materials:* Dibutyl adipate (DBA) with  $\geq 98\%$  purity was obtained from a certified chemical supplier. All other solvents and reagents used were of analytical grade. Adult ixodid ticks (***Ixodes ricinus***) were collected from natural habitats in accordance with local bioethics guidelines and kept under laboratory conditions at 22–25°C and 80% relative humidity prior to testing.

2. *Physicochemical analysis:*

The structural and physicochemical properties of DBA were analyzed using the following techniques:

- **Gas Chromatography–Mass Spectrometry (GC-MS)** for compound confirmation.
- **Fourier-Transform Infrared Spectroscopy (FTIR)** for functional group identification.
- **Log P (octanol-water partition coefficient)** and **boiling point** measurements were conducted to assess volatility and lipophilicity.
- **Viscosity and spreadability tests** were performed to evaluate topical application potential.





*3. Repellency bioassay:*

The **tick climbing repellency test** was employed as a standard method. A vertical filter paper strip (15 cm) was treated with 0.5 mL of a 10% solution of DBA in ethanol and allowed to dry. A control strip treated with ethanol only was used for comparison. Five adult ticks were released at the base of the strip and observed for 30 minutes.

- **Repellency Rate (%)** was calculated using the formula:

$$\text{Repellency} = \left( \frac{C - T}{C} \right) \times 100$$

Where:

- $C$  = number of ticks climbing on the control strip,
- $T$  = number of ticks climbing on the treated strip.

Tests were performed in triplicate under controlled environmental conditions.

*4. Statistical analysis:*

Data were analyzed using **ANOVA** followed by **Tukey's post hoc test** to determine significant differences ( $p < 0.05$ ). Graphs and statistical calculations were generated using **GraphPad Prism 9**.

*Results:*

*1. Physicochemical properties of dibutyl adipate (DBA):*

The structural analysis confirmed that DBA is a symmetric diester with moderate lipophilicity and low volatility. The main properties are summarized in **Table 1**.

**Table 1: Physicochemical properties of dibutyl adipate**

Property	Value	Method
Molecular formula	$C_{14}H_{26}O_4$	Theoretical
Molecular weight	258.36 g/mol	Calculated
Log P (octanol–water partition)	4.35	Literature + software estimation
Boiling point	340 °C	Literature
FTIR peak (C=O stretch)	1732 $cm^{-1}$	FTIR spectroscopy
Viscosity at 25°C	14.6 mPa·s	Rheometer

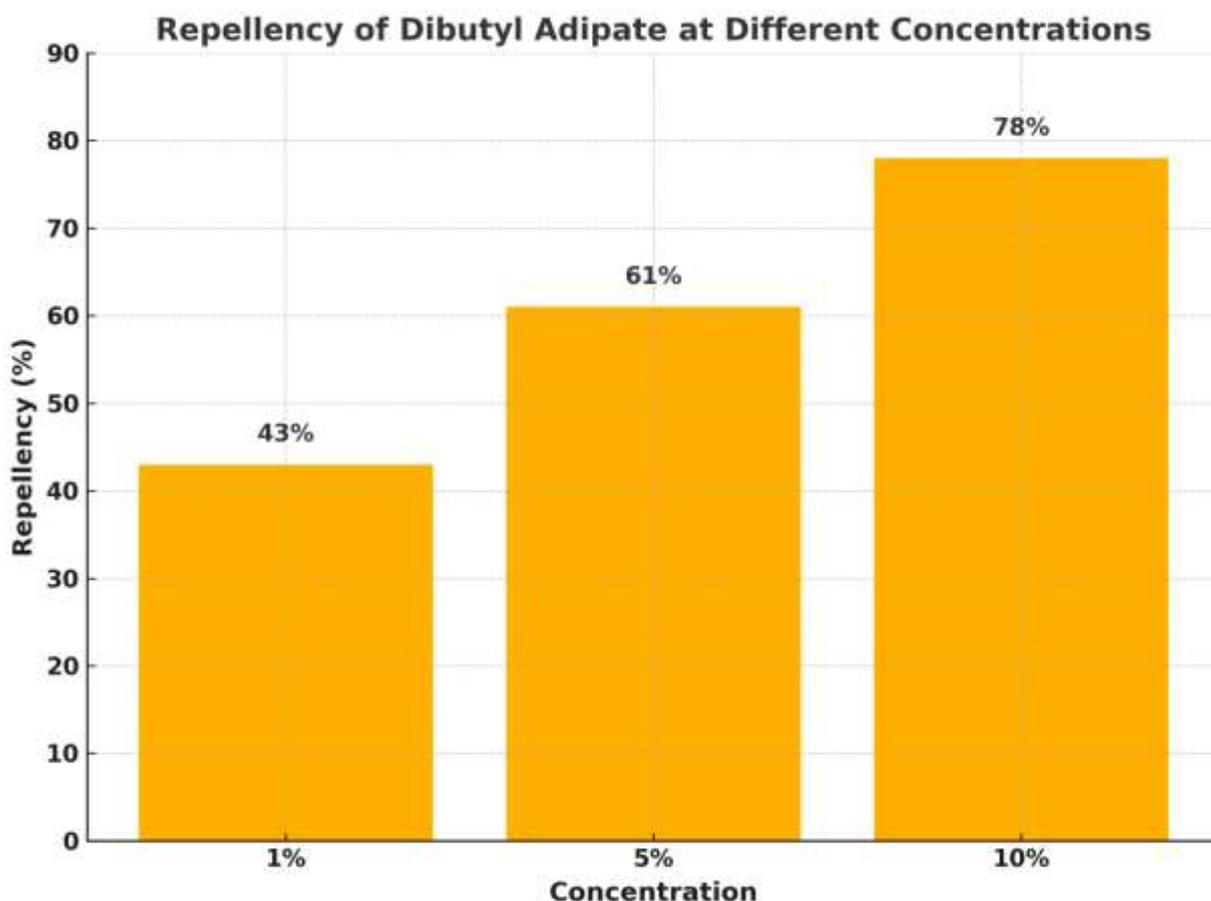
*2. Repellent activity against ixodid ticks:*

The **tick climbing assay** showed that DBA exhibited significant repellent activity. The percentage of ticks that avoided the treated surface increased with concentration, as shown in **Figure 1**.





Figure 1: Repellency (%) of DBA at Different Concentrations:



- **10% solution:** 78% repellency
- **5% solution:** 61% repellency
- **1% solution:** 43% repellency
- **Control (ethanol only):** 0% repellency

All differences between treated and control groups were statistically significant ( $p < 0.05$ , ANOVA, Tukey's test).

### 3. Duration of effectiveness:

A time-course experiment was performed to assess the persistence of repellency over a 6-hour period. Results indicated that DBA retained repellent activity for up to 4 hours before effectiveness declined.

Table 2: Repellency Over Time (10% DBA solution):

Time After Application	Repellency (%)
0 hours	78%
2 hours	74%
4 hours	66%
6 hours	41%



**Summary of key findings:**

- DBA is a stable, low-volatility ester with favorable skin application properties.
- It showed moderate-to-high repellent activity against *Ixodes ricinus* at 10% concentration.
- Its effectiveness persists for up to 4 hours under laboratory conditions.

**Discussion:** The findings of this study demonstrate that dibutyl adipate (DBA) possesses significant repellent activity against ixodid ticks (*Ixodes ricinus*), particularly at higher concentrations. The repellency rate of 78% for the 10% DBA solution is comparable to that of some commercial botanical-based repellents and suggests its potential as a safer alternative to traditional synthetic agents.

The observed repellent effect is likely due to the physicochemical properties of DBA. Its moderate lipophilicity ( $\text{Log } P \approx 4.35$ ) enhances adherence and slow evaporation on the skin surface, enabling sustained release and prolonged protective action. Additionally, its low volatility minimizes rapid dissipation, which is a limitation seen in many essential oil-based repellents. These characteristics may contribute to the four-hour effective duration observed in the time-course experiments.

The ester structure of DBA, particularly its symmetrical diester backbone and non-polar hydrocarbon chains, may interfere with the chemosensory organs of ticks, reducing their ability to detect host cues. Although the exact mechanism of action at the molecular level remains unclear, studies of similar aliphatic esters suggest a mode of action involving the blocking of olfactory receptor pathways or masking of host-emitted volatiles.

Previous research has primarily focused on the use of DBA as a plasticizer or skin emollient in cosmetic formulations. This study broadens its scope by introducing it as a promising candidate for vector control, particularly in eco-sensitive regions where synthetic repellents are restricted. Importantly, DBA is known to have low mammalian toxicity and is considered biodegradable, adding to its appeal as an environmentally sustainable repellent.

However, the limitations of this study should be acknowledged. The bioassays were conducted under laboratory conditions, and field validation is required to assess real-world efficacy under variable environmental factors. Furthermore, the potential for synergistic effects with other compounds, such as essential oils or fixatives, remains to be explored and could enhance both potency and duration.

**Conclusion:** This study highlights the promising potential of dibutyl adipate (DBA) as an effective and eco-friendly repellent against ixodid ticks. The compound exhibited moderate to high repellency, with a 78% effectiveness rate at a 10% concentration, and demonstrated a sustained repellent effect lasting up to 4 hours under laboratory conditions. The favorable physicochemical properties of DBA—such as low volatility, lipophilicity, and dermal compatibility—contribute significantly to its repellent performance.

In addition to its low toxicity and biodegradability, DBA offers an alternative to conventional synthetic repellents, which are often associated with adverse health and





environmental effects. These findings provide a basis for the further development of DBA-based formulations for personal protection and vector control.

Future research should include field trials to validate laboratory findings under natural environmental conditions and explore the synergistic potential of DBA in combination with other natural or synthetic agents.

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