שינוי אמת

Shinui Emet

How the Talmudic Tests for Kala Ilan Distinguished Murex Trunculus Techelet from Its Imitations

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For Questions & Discussions
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Menachot Talmud Bavli 42b-43a

ותכלת אין לה בדיקה והא רב יצחק בריה דרב יהודה בדיק ליה (סי' בגשם) מייתי מגביא גילא ומיא דשבלילתא ומימי רגלים בן ארבעים יום ותרי לה בגווייהו מאורתא ועד לצפרא איפרד חזותיה פסולה לא איפרד חזותיה כשרה ורב אדא קמיה דרבא משמיה דרב עוירא אמר מייתי חמירא ארכסא דשערי ואפיא לה בגוויה אישתנאי למעליותא כשרה לגריעותא פסולה וסימניך שינוי שקר שינוי אמת מאי אין לה בדיקה נמי דקאמר אטעימה מר ממשכי אייתי תכלתא בשני רב אחאי בדקוה בדרב יצחק בריה דרב יהודה ואיפרד חזותיה בדרב אדא ואישתנאי למעליותא סבר למיפסלה אמר להו רב אחאי אלא הא לא תכילתא היא ולא קלא אילן היא אלא שמע מינה שמועתא אהדדי איתמר היכא דבדקנא בדרב יצחק בריה דרב יהודה לא איפרד חזותיה כשרה איפרד חזותיה בדקינן לה בדרב אדא בחמירא ארכסא אישתני למעליותא כשרה לגריעותא פסולה שלחו מתם שמועתא אהדדי איתמר

And is there no testing Techelet? But didn't Rav Yitzḥak, son of Rav Yehuda, test it (a mnemonic GSM). Bring alum [gavya gila], and water of fenugreek [mei shavlilta], and urine [mei raglayim] forty days old. Soak the sample in this from night until morning. If its appearance would separate [ipparad ḥazutei], unfit, its appearance would not separate, fit. And Rav Adda said before Rava in the name of Rav Avira: One brings overripe barley sourdough and bakes it inside. If it changes for the better, it's kosher. If it changes for the worse, unfit. And your mnemonic "Change of falsehood - change of truth." What when it says: There is no testing, for tasting (a test vat or wool which would be unfit due to Maareh Sheni). Mar from Mashkhei, brought Techelet in the years of Rav Aḥai. They tested it in Rav Yitzḥak, son of Rav Yehuda's test, and its appearance separated. With the test of Rav Adda and changed for the better. They thought deemed unfit. Rav Aḥai said to them: But how can this wool not be tekhelet, and is also not Kala Ilan? Rather, conclude from it that these halakhot were stated together. Where we tested the wool in by Rav Yitzḥak, son of Rav Yehuda, and its color did not separate, it is fit and requires no further testing. If its color separated, we test it in by Rav Adda, with hard leavened, changed for the better it is fit; if the color changed for the worse it is unfit. They sent from there, the statements were made together.

Introduction

Over the last 30 years, the Jewish world has witnessed a revival of *Techelet*, a mitzvah once thought lost to history. Through new discoveries, research and sincere passion, many have embraced the Murex Trunculus sea snail and its dye as what they believe to be the true ancient Techelet. But as with any revival, the story doesn't end at discovery, it is a dynamic process that continues through ongoing insights, research and developments.

Our sages in the Gemara *Menachot*, didn't just describe *Techelet,* the laws and details, they gave us a way to test it against fakes called Kala Ilan. The two testing methods preserved there weren't just theoretical, it was a tool to distinguish the authentic Techelet from the imitation and to ensure that *Techelet* would be and remain authentic for the Mitzvah of tzitzit and the Temple service.

After the second test mentioned in Menachot confirmed the test sample as true Techelet, Chazal described a moment of clarity, they called it a *Shinui Emet*, a change that reveals the truth. A change *l'maalyuta*, for the better. A transformation visible to the human eye that undeniably proves that this Techelet is authentically from the hilazon shel Techelet, in the proper royal color range and proper to use for the mitzvah. It was more than a sign of authenticity for that moment, it was proof that Chazal in their brilliance embedded the secret of Techelet within the sugya itself, so that in our time the genuine dye source *and its authentic color* could be rediscovered with faithfulness to the original Techelet of the Mishkan and Temple in Jerusalem.

The title of this paper, Shinui Emet, carries a deeper meaning, as well. Sometimes we cannot reach a deeper truth without additional investigations, testing and refining. This deeper investigation, can bring a change l'maalyuta, for the better, that proves authenticity and confirms truths. In fact, the very essence of *Techelet* is connected to truth. Its very name shares a root with truth, Tachlit. *Tachlit* is the true intention and final resolution of a matter, the *Emet*. *Techelet*, then, is not simply a colored string, it is a symbol of truth tied to the four corners of the garments of Israel. It represents remembering and recognizing the truth, choosing the truth, and our belief in the ultimate truth of HaShem's omnipresence and awareness over the created universe.

Our Sages tell us that one who intentionally wears (or sells) *Kala Ilan*, the counterfeit dye, and passes it off as *Techelet*, will face divine retribution. Not merely because he counterfeits a mitzvah, but because he misrepresents the very symbol of God's eternal truth and omnipresence. Chazal connects this fraud to the night of *Yetzias Mitzrayim*, when God Himself made the ultimate separation between the firstborn of the Egyptians and the firstborn of Israel. That same divine precision and standard of judgment still applies today to the mitzvah of *Techelet*. There is no room for assumptions, close enough, and surely no room for counterfeits.

This paper does not aim to dismiss what has been achieved till today, the discovery of Murex Trunculus as the source of Techelet and the Techelet revival movement is a monumental achievement and shift for our nation, bringing us to the doorstep of Geulah and the rebuilding of the Temple in Jerusalem. Rather, this paper seeks to go further to fulfill and bring the mitzvah of Techelet to its *tachlit* and to ensure that what we call *Techelet* is not just from the correct intention and source, but a historically and halachically *functional true and authentic* Techelet color as well. Only then can we say that the mitzvah has returned in its entirety. On our tzitzit today, and in the coming Third Temple in our times.

Chapter 1 - Bein Techelet L’Kala Ilan

Techelet, the Biblical dye, was one of the most coveted colorants in the ancient world. It wasn’t just a rare or luxury dye, it was sacred to Jews in that it is a biblical commandment that marked priesthood and divine service and a mitzvah required by each jew to wear. Whether used in the garments of the Kohen Gadol or on the tzitzit of a common Jew, Techelet represented a connection between heaven and earth.

Photo: Murex Trunculus Snail & it’s Blue-purple secretion

Beyond the Jewish world, it was prized for its beauty and status. Purple snail dyes were symbols of power worn by emperors, generals, and politicians. These dyes weren’t just expensive, they were politically controlled and tightly guarded by commercial and imperial monopolies from Phoenicia to Rome. Their use was often legally restricted to the elite and in many cultures, to wear these colors without permission was considered a capital offense. Precisely because of its value and exclusivity, Murex snail dyes were commonly imitated. Ancient imitation dyeing recipes were found across cultures and included instructions for faking the costly snail-based purples using cheaper, plant-based ingredients.

This is where Chazal stood apart. They didn’t transmit how the Kala Ilan counterfeit was made, but they did something far more important, they gave us the tests to expose the imitations. Two tests were coded in Gemara Menachot and passed on through multiple generations of rabbis that revealed these forgeries and ensured that the real Techelet source and color are used for all time.

A Modern Challenge To Chazal’s Tests

Alongside today’s Techelet revival came modern assumptions on the very nature of Techelet and its imitation Kala Ilan that challenge the very foundation of Chazal’s words. Fueled by the realization that under strong artificial UV light while chemically reduced for extended periods of time in a transparent glass jar, the natural blue-violet palette of pigments in the Murex Trunculus gland can be degraded to a single pure blue indigotin molecule, a new perspective on the nature of Techelet and its imitation emerged.[1]

Photo: Three shades of Woad dyed yarn.

Naturally, the native Murex Trunculus pigments combine to make a blue-purple permanent color, now they become a single pigment, a one-dimensional pure blue hue matching plant Woad or Indigo, with a process not mentioned historically. The pure blue theory is that both Techelet and Kala Ilan are this very same single blue indigotin molecule, made from a complete UV & chemical-based debromination process not mentioned in Chazal or in secular historical texts, and in truth, not at all possible in ancient times.

[1] THE DYEING WITH MUREX EXTRACTS, AN UNUSUAL DYEING METHOD OF WOOL TO THE BIBLICAL SKY BLUE Otto Elsner and Ehud Spanier, https://tekhelet.com/pdf/Elsner-Dyeing-1985A.pdf

Ancient cultures got their pure blue dye from plants, there would be no need to make pure blue by degrading expensive blue-purple snails to make a product that would be visually and chemically identical to the popular, cheap and freely growing blue plant dye, woad. But the new Techelet model proposed exactly that. Whether derived from difficult to harvest and expensive *Murex Trunculus sea snails* or from the indigo plants like Indigoferra Tinctoria (indigo) or Isatis Tinctoria (woad), it is proposed that indigotin alone, a single blue molecule is the secret of *Techelet and Kala Ilan*.

The first problem is, if we assume Techelet was composed entirely of pure indigotin and a simple pure blue color, it raises very difficult questions about the very artifacts used as evidence of Murex Trunculus based Techelet.

Murex Trunculus dyed textile fragments discovered at Masada (IND 33% MBI 47% DBI 20%)[2] and Wadi Murabba'at (IND 52% MBI 38% DBI 10%)[3], are often cited as direct evidence for Murex-based Techelet, but consistently show a significantly brominated profile. But if Techelet is defined as fully debrominated pure blue indigotin, then these artifacts by that definition would not qualify as authentic Techelet at all.

Photo: Murex Trunculus dyed wool artifact found on Masada.

And if these artifacts are indeed the true Techelet from the Murex Trunculus, then we are wearing something today which would not have been considered Techelet to our ancestors at all.

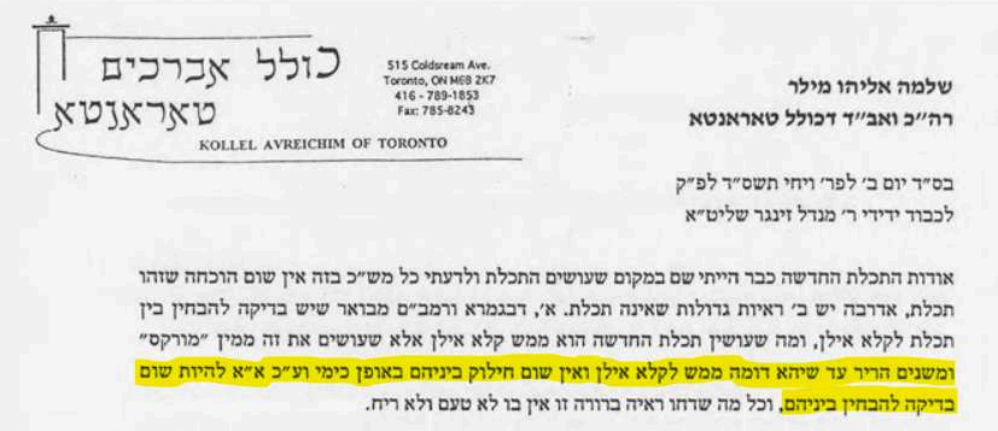
Profile of Murex Artifacts Compared To Plant[4] & Synthetic Indigos

Sample	IND (%)	MBI (%)[5]	DBI (%)	INR (%)
Masada	33	47	20	*na*[6]
Wadi Murabba'at	52	38	10	""
Indigofera tinctoria	85	0	0	15
Isatis Tinctoria	97	0	0	3
Synthetic Indigo	100	0	0	0

[2] "Tekhelet: Setting the Ancient Record Straight", Zvi C. Koren, https://traditiononline.org/wp-content/uploads/2022/01/54.1-Koren.pdf
[3] "Chemical analysis of Murex-dyed textiles from wadi Murabba'at, Israel", https://tekhelet.com/pdf/Sukenik.pdf
[4] The indigotin/indirubin percentages shown are rounded, representative estimates based on peer-reviewed HPLC and related analyses of woad and indigo materials. Actual ratios can vary with plant source, year, and processing method.
[5] The true defining molecule of Techelet is MBI not IND. Without MBI, no sample of Murex would be identifiable as from the Murex Trunculus.
[6] Not tested for indirubin and brominated indirubins, newer tests calibrated for indirubins show significant indirubins as in Kition. https://hal.science/hal-05079453v1/file/AEGIS%2030_V5_2025-04-07_ISBN_Chapter%207.pdf

But here is the bigger contradiction;

If Techelet and Kala Ilan are chemically identical, both pure indigotin, then the tests prescribed by Chazal are meaningless.[7] No amount of visual inspection, fermentation, alkaline, acid or heat would distinguish a pure blue snail indigotin dyed wool from a plant indigotin dyed wool, it's the exact same molecule. So to agree to today's pure blue Techelet theory, one would have to dismiss the very same talmudic tests of Techelet and its imitation Kala Ilan as theoretical and non-functional, or even worse, irrelevant. And yet, Chazal insisted the tests worked, they rendered verdicts of kashrut while the tests were in use and they built halacha on this foundation.



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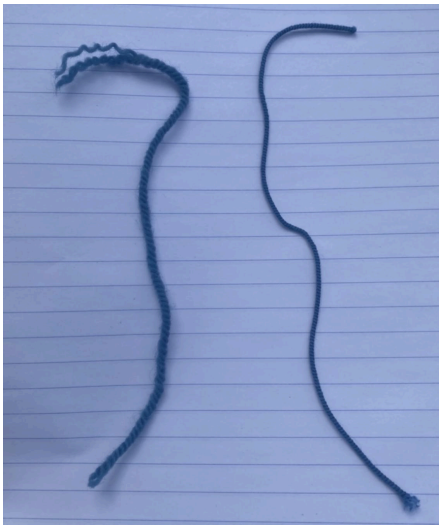
שלמה אליהו מילר
רה"כ ואב"ד דכולל טאראנטא

בס"ד יום ב' לפר' ויחי תשס"ד לפ"ק
לכבוד ידידי ר' מנדל זינגר שליט"א

אודות התכלת החדשה כבר הייתי שם במקום שעושים התכלת ולדעתי כל מש"כ בזה אין שום הוכחה שזהו תכלת, אדרבה יש ב' ראיות גדולות שאינה תכלת. א', דבגמרא ורמב"ם מבואר שיש בדיקה להבחין בין תכלת לקלא אילן, ומה שעושין תכלת החדשה הוא ממש קלא אילן אלא שעושים את זה ממין "מורקס" ומשנים הריר עד שיהא דומה ממש לקלא אילן ואין שום חילוק ביניהם באופן כימי וע"כ א"א להיות שום בדיקה להבחין ביניהם, וכל מה שדחו ראיה ברורה זו אין בו לא טעם ולא ריח.

Photo: Letter from Rav Shlomo Miller to Dr. Mendel Singer regarding the modern indigotin Techelet



Left photo: Pure Blue from plant (left string) and pure blue from murex snails (right string). Right photo: After reduction in a blank reduction vat both clearly reduced to colorless wool, they are identical chemically.

[7] Rabbi Shlomo Miller of Toronto Kollel, Moetzes Gedolei HaTorah, "ואין שום חילוק ביניהם באופן כימיו ועל כן אי אפשר להיות שום בדיקה להבחין ביניהם", https://www.techeiles.org/library_main/michtav-harav-shlomo-miller/

Today’s Concern

This isn’t just a theoretical concern, if Chazal’s tests are dismissed as theoretical or non-functional, then we risk more than just misinterpreting a sugya, we risk observing the mitzvah with the wrong Techelet. A model that equates Techelet and Kala Ilan as chemically identical indigotin, severs the link between the ancient authentic Techelet and our reality today. It leaves us without a viable way to guard against imitations and it replaces Chazal’s functional Techelet & Kala Ilan with a symbolic modern abstraction.

The danger isn’t just that the sugya in the Gemara becomes a metaphor, it’s that our own modern Techelet becomes a metaphor too.

We Are Forced To Choose - Techelet Or Theory

So now, we are forced to choose, either Techelet’s authentic colorant profile and Chazal’s tests are abandoned as irrelevant to today's Techelet revival, or that the modern assumption that Techelet and Kala Ilan are chemically identical is wrong. This paper takes the second path. I show that Chazal's tests were real and effective and therefore we must accept them at face value. There was a functional, detectable difference between real Techelet and the forgeries that imitated it.

Drawing from historical imitation recipes and ancient Talmudic test replications, I present the working model for both Techelet and Kala Ilan, not as pure indigotin blue, rather, Techelet as a blue-purple from the Murex Trunculus sea snail, and Kala Ilan as a blue-purple overdye imitation.

In the next sections, we’ll break down those tests. But first, we must examine the assumptions that got us here and why the original concept of Kala Ilan became misunderstood over time.

Chapter 2 - What Was Kala Ilan?

Worth More Than Gold

The most valuable dye known to the ancient world came from a sea snail. The purple gland of the Murex sea-snail yielded a range of purple colors so brilliant and colorfast that true purple dyed textiles were worth their weight in gold. But wherever there is a potential profit replacing expensive luxury goods with cheaper ingredients, imitations and opportunists will arise. From early Mesopotamia to the Roman Empire, dyers sought to recreate the snail dye colors using cheaper plant materials. These forgeries were very common in the marketplace and their recipes were jealously guarded.

The rabbis of the Talmud warned of these imitations they called Kala Ilan, a lookalike invalid for the mitzvah. But what was Kala Ilan? Most modern readers assume it simply refers to plant-based indigo. But this chapter will show that Kala Ilan was actually crafted by the overdyeing of common dyes and the mixing of basic colors.

Photos: Historical ingredients used to make Kala Ilan; Indigo dyed yarn, alum & madder, based on the Sippar Cuneiform and Papyrus sources.

Understanding Ancient Dyeing - Vat and Mordant Systems

To understand how Kala Ilan was constructed, and how Chazal exposed it, we need to first clarify the two main dyeing systems used in the ancient world: vat dyes and mordant dyes.

Dye Method	Examples	Process	Chemical Environment
Vat Dye	Indigo, Woad, Murex	Fermentation and reduction vat, followed by air oxidation	Alkaline, High PH, oxygen-free during vatting
Mordant Dye	Madder, Kermes	Heated dye bath with premordanted wool	Acidic, Low PH, with heat

Vat dyes, such as indigo and Murex, are insoluble in water and must first be chemically reduced in an alkaline solution, typically fermented urine, wood ash and plant materials. Once reduced, the wool is soaked in the vat and then removed and exposed to air, where the dye oxidizes and binds inside the fiber. This process produces a very stable and colorfast bond without the need for any acidic mordant or added heat. The dye becomes part of the fiber's structure.

Mordant dyes[8], like madder and kermes, work differently. These dyes are water-soluble but chemically unstable on their own. They require an acidic metal mordant, such as alum or iron, to adhere to the fiber first. Heat is also required, simmering over time in the dye bath, to properly fix the dye to the wool.[9]

These two methods are chemically incompatible and cannot be combined in a single dye bath. A vat dye requires an alkaline high-pH, oxygen-free environment. A mordant dye needs acidic low PH, acidic metal salts and sustained heat. Attempting to mix both at the same time would destroy one or both reactions. You can't just throw the ingredients together, the only way to use both is in separate steps.

Photo: Madder dyed over Indigo.

1. First, dye the wool dark blue using a fermentation vat.
2. Then mordant the wool, and simmer in a bath with the red dye.

Imitation Snail Color Dyeing Recipe History

Sippar - The First Documented Overdye Recipe for Blue Purple Techelet - Takiltu[10]

In a cuneiform tablet from Neo-Babylonian Sippar, from around the **First Temple Period**, we find the earliest surviving recipe for transforming blue-dyed wool into a blue-purple imitation. The term used is Takiltu, a word linguistically related to the Hebrew Techelet, and used for blue-purple luxury-dyed materials in the Mesopotamian world. First the tablet describes how to make two grades of pure blue wool, a dark lapis-lazuli blue dipped multiple times in a strong indigo vat, which is even replenished mid-dyeing to be even darker, called **Uqnatu.** And a light blue dipped three times in the leftover exhausted Uqnatu vat, called **Urriqu**.

Photo: Sippar Dye Cuneiform

The tablet then explains how to make purple colors from Uqnatu & Urriqu blue wool. For **Takiltu blue-purple**, the tablet begins with pre-dyed, dark lapis lazuli-blue **Uqnatu** wool, then instructs to mordant the wool with alum (gabu) then to overdye the wool with a red plant dye called Haritu which is Madder. This two-stage process results in a composite color, a red layer over a dark blue base, yielding a dark blue-purple hue called **Takiltu**.

"To dye uqnâtu to takiltu - You weigh out uqnâtu (Blue Lapis-colored wool) and alum in equal proportions, boil them up in water on the fire until the water is all gone. You boil up crushed madder (hat-huritu) and the uqnâtu wool in equal proportions in water on the fire. When you take it out (you will have) takiltu wool."

[8] https://en.wikipedia.org/wiki/Mordant
[9] https://botanicalcolors.com/how-to-mordant/
[10] https://www.tekhelet.com/pdf/0872.pdf

(1st Argamannu Recipe) "To dye urriqu to argamannu (pale blue wool to red-purple Wool] - You put kasu in water, and boil it up on the fire. You strain it, and put the urriqu wool in it. You boil it up on the fire. When you take it out (you will have) argamannu wool."

(2nd Argamannu Recipe) "To dye urriqu to argamannu (pale blue wool to red-purple wool] - You weigh out urriqu wool and alum in equal proportions, and boil (them) up in water on the fire until the water is all gone. You boil up crushed-madder (hat-huritu) and those flocks of urriqu wool in equal proportions in water and "clay water" on the fire. When you take it out (you will have) argamannu wool."

What the Sippar Tablet Shows:

Wool Type	Recipe Process	Final Hue	Logogram	Compare To
Uqnātu	Dark blue wool that was dipped 3 dips in a full strength Indigo vat, then the vat is replenished with more dye and the wool dipped 3x more times	Dark Lapis Lazuli Blue	SÍG.ZA.GÌN[11]	Isatis/Indigo
Urriqu	New wool added in the exhausted Uqnatu vat dipped 3x	Light Blue/Sky Blue	SÍG.SIG7[12]	Isatis/Indigo
Ḫašmānu	Dark Blue Lapis Lazuli Uqnātu wool overdyed with a yellow mordant dye (likely weld)	Dark Green	SÍG.HAS.MA.NU[13], SÍG.ZA.GÌN.*ḫašmāni*[14]	Karti
Takiltu	Dark Blue Lapis Lazuli Uqnātu wool, overdyed with Red Hat-Huritu Madder	Deep, Dark Blue-Purple	SÍG.ZA.GÌN.KUR.RA[15]	Techelet
Argamannu	Two recipes; light-Blue Urriqu overdyed with Hat-Huritu Red Madder or Kasû (likely orchil)	Red-Purple	SÍG.ZA.GÌN.SÁ[16]	Argaman
Tabarru	Huritu Madder only, describes 3 types; Huritu, Hat-Huritu & Inza Huritu	Madder Red	SÍG.HÉ.ME.DA[17]	Puah

[11] CAD *Uqnatu,* https://isac.uchicago.edu/sites/default/files/uploads/shared/docs/cad_u_w.pdf
[12] https://badwcai-ebl01.srv.mwn.de/dictionary/urr%C4%ABqu%20l
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Understanding The Cuneiform Names For Dyed Wools

In the cuneiform lists, ***ZA.GÌN*** is a logogram that means lapis-like and marks the whole family of lapis lazuli-like materials including stones and a range of textile colors. When preceded by ***NA***, it refers to the stone lapis lazuli itself, ***NA.ZA.GÌN***.

When preceded with ***SÍG,*** it refers to wool/sipatu, and refers to a range of colored wools including Indigo, Techelet and Argaman. Each specific ***ZA.GÌN*** dyed wool is then clarified by a qualifier. So you find ***SÍG.ZA.GÌN*** = dark blue lapis-lazuli *uqnatu wool*, ***SÍG.ZA.GÌN.KUR.RA*** = "Exotic/Foreign" dark blue-purple *takiltu* wool and ***SÍG.ZA.GÌN.SA*** = "Red" bright red-purple *argamannu* wool.

Techelet aligns with *takiltu (**SÍG.ZA.GÌN.KUR.RA**)*, the blue-purple wool, not with *uqnu (general "lapis-like" term) or uqnatu (**SÍG.ZA.GÌN**, indigo lapis-lazuli wool)*, as shown in the Sippar Cuneiform.

To collapse all ***ZA.GÌN*** or ***SÍG.ZA.GÌN*** names into one hue, shade or product would erase the careful distinctions the scribes and artisans themselves made for specific materials and dyes. The fact that the Sippar cuneiform includes dark lapis-blue Uqnatu wool, light blue Urriqu wool, red-purple Argamannu wool and blue-purple Takiltu wool appearing side by side, and clearly describes how the Takiltu color can be achieved with Uqnatu overdyed with Madder red, shows they understood these as different color classes.

Pseudo-Democritus Book *On Purple*

"Pseudo-Democritus" wrote four alchemical books on dyeing, *On Gold, On Silver, On Stones and On Purple*. The book *On Purple is mostly lost*, but what is still available through secondary sources, is one recipe to make imitation purple, and a list of ingredients used in making imitation purple including; woad, madder, several types of kermes, alkanet & orchil.

The Cave of Letters - Overdyed Imitation Purple

In the 1960s, archaeologist Yigal Yadin uncovered wool fragments in the Bar Kochba caves dyed in royal bluish purple color. A first suspected to be true blue-purple made with a sea snail, only after further scientific analysis was the true situation revealed. The imitation was made with a two-stage formula, an overdyeing of indigo and the red insect dye, kermes.

Photo: Kermes and overdyed Wool from Bar Kochba cave.

Egypt - The Recipes of a Master Counterfeiter

By the 3rd to 4th centuries CE, Egypt had become a hub of dye production under Roman rule. What survives from this period is a collection of technical manuals, the **Leiden[18] and Stockholm[19] papyri**, which record over a hundred purple dye recipes, including blue-purple overdye recipes. These documents

[18] https://en.wikipedia.org/wiki/Leyden_papyrus_X
[19] https://en.wikipedia.org/wiki/Stockholm_Papyrus

were not found in libraries. They were jealously guarded and literally found buried with the dye master himself, a testament to the secrecy of the trade and imitation methods.

Recipe 153 from the Papyrus; Dyeing of Madder Purple.

***After bluing**, sprinkle the wool with ashes and trample it down with them in a convenient manner. Then press (the) liquid out of potter's clay and wash off the blued wool therein. Rinse it in salt water and mordant it. You will know if it is sufficiently mordanted when it sinks down in the kettle and the fluid becomes clear. Then heat rain water so that you cannot put your hand in it. Mix roasted, pulverized and sifted madder root, i.e., madder, with white vinegar, a half a mina of madder to a mina of wool, and mix a quarter of a choenix of bean meal with the madder root. Then put these in a kettle and stir up. Then put the wool in, in doing so, stir incessantly and make it uniform. Take it out and rinse it in salt water. If you wish the color to take on a beautiful gloss and not to fade, then brighten it with alum. Rinse the wool out again in salt water, let it dry in the shade and in doing so protect it from smoke.*

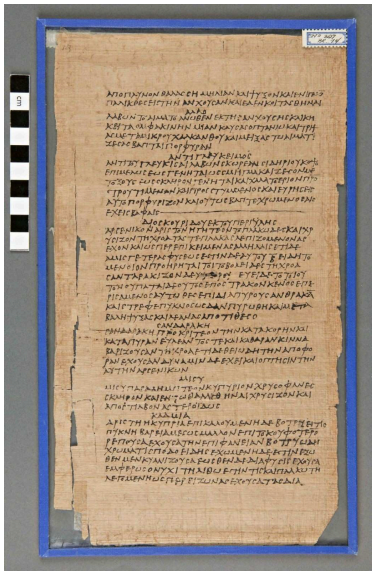

Photo: Page 14 of the Dye Papyrus

Contemporary Topics In Early Chazal

Around the same time, the **Tosefta** and the **Sifre**, contain include early discussions about Kala Ilan:

Proof From Tosefta Avoda Zara - A Vat Of Kala Ilan

ובור **קלא אילן**[20] שרשה[21] בעצי אשרה ישרף אחרים אומרים מטילין אותה לחומר עד שיחזרו מראיו לכמות שהיה[22]

According to Rabbi David Pardo, and quoted in the Radzyner Rebbe[23], this Tosefta refers to a *Bor Shel Kala Ilan*, a dye bath of imitation Techelet, that had been heated using the wood of an *Asherah* tree.

This detail is telling. Heat and fire are used in red mordant dye baths, not in blue indigo or woad fermentation/reduction vats (an indigo vat would be ruined by boiling and needs no applied heat in warm climates).

This shows Kala Ilan was not simply indigo or woad by itself, but a known overdye recipe designed to imitate Techelet. In this case, they

[20] Remarkably, the gematria of Kala Ilan, 222, (קלא אילן) = is the exact sum of Istis (אסטס) + Puah (פואה), the two ingredients of the classic forgery recipe.
[21] Several manuscripts use varied language; שדשו/שדשה/שרשה/שרשם
[22] Avodah Zarah (7:1)
[23] Ptil Tekhelet 4

began with blue wool and then overdyed it with a red mordant dye using heat from burned wood from an Asherah, rendering the final product forbidden.

The blue wool was kosher, and even the red dye itself was kosher, the true forbidden benefit from idolatry was only from the fire heating the mordant dye bath adding the red on top of the blue. Although the first opinion forbids the wool completely as an idolatrous benefit and declares the wool liable to be immediately burned, others allow the wool to remain unburned but in a state of restriction, until the benefit can be removed.

Unlike vat dyes such as woad or indigo, which bond so strongly to wool that they cannot be removed, mordant dyes are less colorfast. With the right methods, known to expert dyers and to Chazal, the red overdye could be damaged or even stripped away, restoring the wool to its previous blue state.

The Radzyner mentioned the connection between מטילין אותה לחומר from the Tosefta case and the second test, Hamira Arkesa, implying a similar chemistry[24]. Actually, מטילין אותה לחומר simply means putting the wool in a state of restriction[25] until the overdyeing is removed and the wool returns to its original state. But we will soon see that the Radzyner was on to something here.

Sifrei Bamidbar – Tzivonim and Kala Ilan

The Sifrei on Bamidbar warns against falsifying the mitzvah of Techelet:
"אלא שלא יאמר הרי אני נותן צבעונים וקלא אילן והם דומים לתכלת ומי מודיע עלי"

The text lists two separate cases, *Tzivonim* (colorants) or *Kala Ilan*, joined by a disjunctive ו ("or"), not as a single combined recipe. This is similar to the Mishnah in Megillah (*אַף מִי שֶׁהָיוּ יָדָיו צְבוּעוֹת אִסְטִיס וּפוּאָה*), where two distinct dyes are listed separately, as well other disjunctive set lists in mishna.

Here, both cases are fraudulent:

1. **Tzivonim** - Any dye or combination of dyes falsely declared as Techelet, including Isatis (woad)[26]
2. **Kala Ilan** - The known imitation recipe designed to match the true appearance of Techelet.

The order in the Sifrei, colorants first, Kala Ilan second, confirms they are separate categories. One is any substitution with common dyes; the other is the specific, historically known forgery meant to pass as authentic Techelet.

As well, *והם דומים,* a plural disjunctive descriptive, showing that the Sifrei speaks of two distinct cases. Both the "colorants" declared as and Kala Ilan separately resemble Techelet.

When Techelet Was Lost & Kala Ilan Was No Longer Viable

Most scholars agree that authentic Purple production ended progressively over the Roman, Byzantine, and Arab transitions. By the time of the Geonim the chilazon was no longer accessible at all for the mitzvah, and the tests for Kala Ilan became theoretical rather than practical.

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[24] Ptil Tekhelet 4 - אכן מה שפי' מטילין אותה לחומר, כלומר לסיד שמסיר הצבע עד שיחזיר מראיתו לכמות שהיה יעו"ש
[25] Shabbat 34b
[26] Sheviit 7: *וּמִמִּין הַצּוֹבְעִים, סְפִיחֵי אִסְטִיס*.

By the early medieval period, the direct experience of Murex dyeing had disappeared, the Roman Empire had collapsed, and with it the infrastructure for harvesting, fermenting, and preparing the royal snail dye. What remained was just a distant memory, simply contextual and conceptual.

Yet in the early stages of this transition, the distinction between authentic Techelet and Kala Ilan was still preserved. There was an assumed functional chemical difference between Techelet and Kala Ilan with an expectation of working tests.

Rashi (France 11th Century)

Writing in Northern France, **Rashi** preserves the original rabbinic understanding of Kala Ilan as a **visual counterfeit**. In his commentary to Menachot, he states simply; צבע היא שדומה לתכלת - **קלא אילן** "*Kala Ilan, a color/dye that resembles Techelet*"[27]. He does not define it botanically and does not call it indigo or Isatis.

The Arukh - From Visual Imitation to Botanical Identity (Rome, 1035 – 1106)

The Arukh defines Kala Ilan simply as indigo[28]. Yet this identification was not based on a preserved mesorah, practical dyeing experience with chilazon, or testing, it was a linguistic approximation reflecting the medieval reality in which snail-based Techelet had disappeared and plant-based indigo was the only known blue dye.

אסטס [אינדיך וואס עס פארבט בלאה]. וקוצה בשביעית בגמ' דנתן צמר בגמ' דששה דברים ויש ספרים שכתוב בהן סטיס פי' **איסטיס** אינדקו ובלשון ערבי ני"ל ובלשון ארמי מוריקא.

קלא אילן [קארן בלרא פארבע] טלית שכול' תכלת כל מיני צבעונין פוטרין בהן חוץ **מקלא אילן בקלא אילן** דלא הדר וממי שתולה **קלא אילן** בבגדו ואומר תכלת הוא פירוש אי"נדקו :

Rabbi Nathan ben Yechiel, the Arukh's compiler, drew from multilingual textual sources rather than firsthand knowledge. He equated Isatis with Arabic "*nīl*" (indigo), but also Aramaic "*Morika*"[29], though the latter actually referred to saffron, a yellow dye. This confusion highlights a critical shift, before the Arukh, Kala Ilan was a deliberate visual forgery, a carefully crafted imitation. In the Arukh, Kala Ilan became defined by a single botanical identity alone.

Rambam (Egypt, 12th century)

The Rambam writes:

> "**Even if it resembles the color of the sky**, if it was dyed with *Isatis, shachor*, or *mashchirin*, it is invalid."[30]

By the Rambam's time, the original Murex dye had been lost, the forgery industry forgotten, and all that remained was restrictions based on range estimations to the dark Rakia/Firmament.

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[27] Talmud Menachot 40a
[28] הוא פירוש אי"נדקו
[29] Sefer HeArukh - אסטס - ויש ספרים שכתוב בהן סטיס פי' איסטיס אינדקו ובלשון ערבי ני"ל ובלשון ארמי מוריקא
[30] *Hilchot Tzitzit* (2:2)

These are not synonyms of Kala Ilan; Isatis, Schachor and blackeners (on another base color) are not visually identical. Rather, they are Rambam's steps of logic on a counterfeiter's strategy to mimic similarity to Techelet, known to be dark, and like the firmament. The Rambam is saying, whether you try to fake Techelet's specific dark midnight sky hue with Isatis, with a black dye, or by darkening another hue like blue, green or red, it's invalid.

Rambam's Hand Written Peirush On Mishnayot

Adding to the confusion, in his own Judeo-Arabic *Peirush Al HaMishnah*[31], Rambam simply glosses *Isatis* as *nīlaj/indigo*, but in later Hebrew copyist editions of Rambam's commentary on the Mishna, there are added statements like: ***"...which is used to dye Techelet"*** *to the Hebrew translations mentioning Isatis*.

Mishnah Source	Rambam – Original Judeo-Arabic	Later Hebrew Copyist Gloss
Megillah 4:7	**ואסטס, <u>אלנילג</u>** Istis is al-nilaj, Indigo.	**ואסטיס צבע כדמות תכלת ובערבי פל"ג.** Istis is a dye resembling Techelet, and in Arabic it is called falaj[32]
Sheviit 7:1	**ספיחי אסטיס, <u>אלנילג'</u>, וסמי כד'לך לאנה יחצד וינבת פהו אבדא ספיח**. *"The regrowth (safichin) of Istis, <u>al-nilaj</u>, and things like it, since it is harvested and grows again, it is always considered safiach."*	**ספיחי אסטיס. <u>הוא הצבע שצובעים בו תכלת</u> ונקרא כן מפני שיקצרוהו ויצמח והוא לעולם ספיח.** *"The regrowth of Istis is the <u>dye used to color Techelet</u>, and it's called that because it is harvested and regrows, and it is always safiach."*
Makot 1:5	**קאל ר' יהודה מתעג'בא מן ד'לך. אסטסים היא זו, מאכ'וד' מן אסטיס <u>והוא אלנילג'</u>.** Rabbi Yehuda says, he is amazed at this "Istisim" , this is derived from Istis, <u>which is al-nilaj (indigo)</u>.	**אסטיסים היא זו, גזור מן אסטיס, <u>והוא צבע שצובעים בו בעין תכלת</u>, ונקרא בערבי נל"ג**. "Istisim", this is derived from Istis, <u>which is the dye used to dye something resembling Techelet</u>, and is called nilaj in Arabic."

In fact, Rambam himself said the specific blue of Techelet is not possible to make in his times[33], meaning that any blue including indigo and woad, possible in his times, is not the very same blue of Techelet. This would obviously rule out any blue color produced with pure indigo & woad.

Nowhere, not in his Mishneh Torah, and not in the original Judeo-Arabic of his Peirush on the Mishnah, does the Rambam say that Isatis woad or indigo is the unique sole ingredient in the Kala Ilan of Chazal, nor that it uniquely and exclusively makes the exact color of Techelet.

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[31] The Friedberg Jewish Manuscript Society (FJMS), http://fjms.genizah.org/
[32] Falaj (فلج) in Arabic means irrigation channel, never indigo. Falag irrigation channels were used in indigo dyeing in Oman, see "Indigo In The Arab World", Jenny Balfour-Paul, https://en.wikipedia.org/wiki/Aflaj_Irrigation_Systems_of_Oman
[33] "Tekhelet: Setting the Ancient Record Straight", Zvi C. Koren, https://traditiononline.org/wp-content/uploads/2022/01/54.1-Koren.pdf

From Loss to Rediscovery

Indigo as Kala Ilan became the dominant idea today, because after the true Murex was lost, Kala Ilan was no longer a viable scheme for counterfeiters and therefore its recipe too was forgotten. While the term was flattened to simply indigo, our modern definition of the color of Techelet became redefined, based on a single ingredient in the ancient counterfeits due to a disconnection in the transmission and understanding of Techelet and Kala Ilan.

A Bigger Problem Today

Although the threat of imitation Techelet is no longer a danger, a bigger problem arose today. Just one of the plant dyes that was used in the ancient fraud recipes became the default standard color model by the modern Techelet revival movement. But our modern effort to rediscover Techelet cannot work backwards.

Projecting today's assumptions on the original Techelet & Kala Ilan model doesn't work, not only because it doesn't match the historical record and actual ancient artifacts, but also because it fails the Talmuds very definition as a uniquely testable dye and color, using the two tests of Menachot.

We're not only left with chemically identical Techelet & Kala Ilan, which is an unviable possibility, we also need to dismiss the actual words of Chazal in favor of modern theories and conclusions. But, we cannot define Kala Ilan by its placeholder, especially when hard facts refute that. We can only define it by what Chazal preserved. And what they preserved is not just the name Kala Ilan, it is a series of functional Talmudic tests to prove Techelet's authenticity and to reveal the counterfeit.

Timeline of Kala Ilan

Era	Source	Description	Key Insight
7th-5th c. BCE	**Sippar Tablet**	Blue-dyed Uqnatu wool overdyed with red Haritu madder makes the Takiltu color	**First Temple Period** - First known forgery recipe of Techelet using a compound system
1st-2nd c. CE	**Tosefta, Sifre**	Mentions of Kala Ilan and Isatis/Stis as distinct terms	Chazal do not connect Isatis woad to imitation Techelet
1st-3rd CE	**Pseudo-Democritus**	4th book On Purple discussed methods and ingredients to make imitation purples.	What remains is one recipe and a list of the common ingredients which includes woad, kermes, orchil, alkanet and more

2nd c. CE	**Bar Kochba Caves**	Fragments with indigo + kermes overdye found	Physical evidence of an overdyed forgery in Jewish context
3rd-4th c. CE	**Leiden & Stockholm Papyri**	Dozens of imitation purple recipes	Professional dye manuals for frauds, buried with the dyer
3rd-5th c. CE	**Menachot 42b / Bavli**	Two tests expose Kala Ilan	Distinct & testable Techelet & Kala Ilan
5th-9th c. CE	**Collapse of the Purple & Imitation Industry**	Loss of chilazon dye access, snail dyeing ceases	Techelet & Kala Ilan forgotten
11th c. CE	**Rashi**	Kala Ilan “resembles Techelet”	Defines it visually; no botanical claim made
11th c. CE	**Arukh**	Kala Ilan is indigo	Shifts definition to single ingredient, not intention.
12th c. CE	**Rambam**	Istis / Shachor / Mashchirin	Various dyes that attempt to imitate or resemble the Rakia, the dark firmament.
Post-12th c.	**Later Halacha**	Equate Kala Ilan with indigo	Halachic tradition lost
Modern Era	**Techelet Revival**	UV Indigotin molecule	Does not work with Talmudic tests, mirrors only one molecule of one ingredient of the historical fraud, Kala Ilan becomes an untestable label

Chapter 3 - The Tests Of Techelet

This chapter examines in detail the Gemara's two tests from Menachot, which distinguish authentic Techelet from the counterfeit Kala Ilan. While these tests have been misunderstood due to the modern conception of Kala Ilan, the tests remain scientifically sound and functional when correctly applied to the historical imitation recipes.

Exploiting Weaknesses In Vat & Mordant Dye Chemistry

While indigo, woad, madder and kermes dyes were some of the most colorfast dyes known to the ancient world, expert dyers - and Chazal - knew that these dyes have specific weak points that can be exploited to reveal their true nature and expose the counterfeits. The two tests mentioned each had a different purpose, targeting a different weakness in one of the two ingredients and their unique dyeing processes.

The first test will reduce blue & purple vat dyes momentarily into their colorless leuco state, identifying if there is a hidden red mordant dye based overdyeing which makes the sample only appear like snail purple. If there is a red overdyeing the test will cause the fakes to briefly turn red, it's colors split, because only the vat dyes reduce, leaving the mordant dyes showing.

The second test will weaken the red mordant overdyes, revealing the blue vat based color underneath, changing the wool permanently for the worse towards blue. While a true Murex blue-purple dye will darken or improve its dark blue-purple hue due to the buffered heat and mild acidic exposure.

Dye	Exploit	Test	Effect	Outcome
Vat Dyes - Murex, Indigo, Woad	Vat dyes will temporarily go colorless in an alkaline blank reduction vat	Fermented urine test vat, no dye added so the vat dye in the sample itself reduces	Reduction hides the vat color and reveals if there are overdyed non-vat dyes, fraud briefly turns red	Fraud is revealed but the vat dye only stays reduced for moments before it reverts to the Kala Ilan color again when exposed to oxygen, can cause confusion
Mordant Dyes - Madder, Kermes	Mordant dyes will break down in acidic conditions combined with sustained heat	Barley Sourdough starter baked in the oven with the sample inside	Acidic steam in baking sourdough breaks down mordant dyes, reveals the more colorfast blue vat dye, permanantly turns more blue.	Permanently damages the color of fakes, doesn't revert to Kala Ilan. Also improves color of the authentic Techelet

Test One - Alkaline Blank Reduction Vat

ותכלת אין לה בדיקה והא רב יצחק בריה דרב יהודה בדיק ליה (סי' ב**גשם**) מייתי מ**ג**ביא גילא ומיא ד**ש**בלילתא ו**מ**ימי רגלים בן ארבעים יום ותרי לה בגווייהו מאורתא ועד לצפרא איפרד חזותיה פסולה לא איפרד חזותיה כשרה.

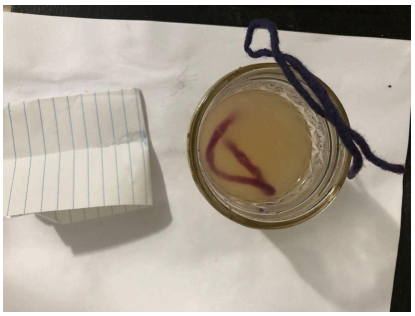
"There's No Test For Techelet? What about Rav Yitzḥak, son of Rav Yehuda, he tested it (with GSM) Bring Gavya Gila, water of Shavlilta, and forty-day-old urine and soak the wool in this mixture from evening to morning. If its appearance separated (ipparad chazutei), it was invalid. If it did not separate, it was valid."

How The First Test Works

The first test given by the Gemara uses three ingredients: It was given the mnemonic, GSM for Gavya Gila, Shavlilta, Mei Raglayim. Gavya gila (likely alum), mei shavliltah (likely fenugreek water), and forty day old fermenting mei raglayim (urine). While the exact identities of the first two have been debated, the chemistry behind this test is clear, and most of the reaction depends on just one of the three ingredients.

This test utilizes a fundamental chemical property of vat dyes, specifically murex, indigo and woad, to temporarily change to a colorless leuco state when soaked in a strongly alkaline fermenting and reducing environment. In the first test, by soaking the dyed wool in aged and fermented urine[34] [35] without additional dyes added, a **blank reduction vat** is created. What happens with a blank vat is that when there are no indigos to reduce in the solution, the vat dyes in the wool sample itself reduce and go colorless, clearly revealing whether a (non-vat dye) red mordant overdye is present.

Ipared Chazutei - It's Appearance Separates



If an overdye exists, it becomes visually prominent when the blue dye reduces, causing the sample's overdyed blue-purple color profile to separate distinctly, turning the wool visually red. Since the red mordant overdye is colorfast in the alkaline reducing environment, it remains and gives away the answer. True Techelet will also reduce considering it is a vat dye, but it will completely reduce to colorless without leaving any red dye overdyes showing, because all of the murex colorants reduce, its appearance does not separate. The separating of the colors from the reduction is the indicator of the counterfeit.

Photo: (left string in jar) Kala Ilan in a blank reduction vat, only the blue reduces changing the appearance to red. (right string) Kala Ilan before blank reduction vat.

[34] https://sharonburnston.com/indigo.html
[35] https://wroot.blog/2015/05/16/a-traditional-indigo-sig-vat/

Urine Test Ingredients

Mei Raglayim (Urine)

Urine that has been left to ferment becomes strongly alkaline and full of ammonia. It was widely used in ancient murex, woad & indigo dyeing, not just as a cleaning agent for wool, but as a reduction base. Vat dyes reduce easily in fermented urine alone, with no additives. This is a well documented indigo dyeing method across multiple traditions, from the ancient world to modern artisan dyers.

Both Rashi and Rambam explicitly mention fermented urine as the essential base of this test. Rashi specifies the urine from a 40-day-old baby, and Rambam states it as urine fermented for forty days.

- **Rashi** - בן ארבעים יום - מתינוק בן ארבעים ל"א שעברו מ' יום משיצאו מגוף האדם (ו)**נתקלקל**
- **Rambam** - וּמֵי רַגְלַיִם **שֶׁנִּתְחַמְּצוּ** אַרְבָּעִים יוֹם

Photo: Indigo reduces in fermenting urine. (source: Caveman Chemistry[36])

Shavlilta Fenugreek Juice

While Rashi interprets Mei Shavlilta as liquid that comes out of fenugreek, - מיא דשבלילתא - מים היוצאין מן התלתן שקורין פנגרי"א, Fenugreek in Hebrew and Aramaic is Tiltan. The linguistic root for the Hebrew and Aramaic comes from ת-ל-ת (three) referring to the three-lobed leaf of the plant and the triangular seeds, which is the same concept as the **Greek Trigonella** (tri-gon = three-angled)**.**

Fenugreek in Persian is Shanbalileh

Fenugreek in Persian is شنبلیله Shanbalileh. While it sounds linguistically close to Shavlilta, Shanbalileh (شنبلیله) in Persian is post-Talmudic and geographically external to Chazal's usage. Shavlilta may have sounded like "shanbalileh" to Rashi or others in contact with Persian medicinal traditions, but not likely the source of this usage.

Fenugreek Water As A Source Of Fermentation Yeasts & Bacteria

In traditional Indian fermentation culture, fenugreek seeds (methi) are widely used for their unique microbial properties. In dosa and idli batters, staples of South Indian cuisine, soaked fenugreek acts as a natural sponge for wild yeasts and lactic acid bacteria, accelerating fermentation and improving rise, texture, and sourness. In some regions, the soaking water alone (methi water) is retained and added to batters to boost microbial activity without even grinding the seeds.

[36] https://www.cavemanchemistry.com/cavebook/chdye3.html

This folk knowledge aligns remarkably with the the first test, which uses מי שבלילתא alongside urine and alum to accelerate the urine fermentation and reduction action on the sample. Fenugreek water functions as a natural fermentation starter, seeding the urine with active microbial agents, enzymes, and mucilage that help create a reducing, alkaline environment.

Rambam Instead Includes Snail Mucus

Rambam connects Mei Shavlilta with Rir Shel Shablul, snail mucus, potentially a source of fermentation bacteria to start or speed up a reduction reaction.

Gavya Gila

Rashi identifies *Gavya Gila* in the Talmud as alum. Alum's primary role historically was to fix and brighten mordant-based dyes, especially reds like madder, on wool. The Akkadian term *gabû* corresponds to alum, showing that Rashi's identification is supported linguistically.

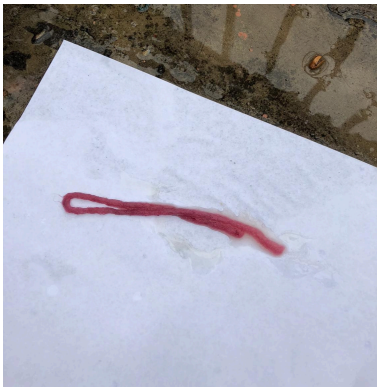
In the context of the first test, alum does not drive the reduction process. In fact, in large amounts its acidity would suppress the alkaline reduction required to reveal hidden dyes. But if only a very small, controlled amount is added, it will not ruin reduction. Instead, it stabilizes, and enhances the visibility of any mordant-based red overdye, making it more noticeable when the blue vat dye is temporarily reduced.

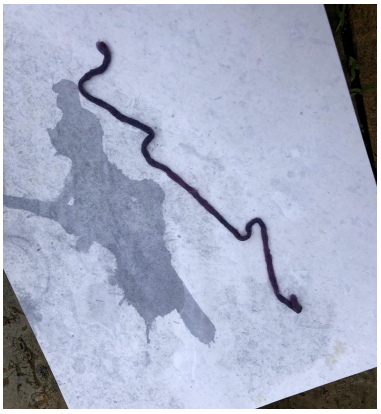
This principle is supported by evidence from Kition[37], where dyers used controlled amounts of **tartaric acid**, a by-product of wine making, another acidic agent, to adjust dye baths. The fact that they knew how to balance acidity so that it improved the dyeing process without destroying it demonstrates the plausibility of alum being used in the first test, in a controlled manner maintaining reduction. Just a pinch or two would be enough to intensify red tones, helping the examiner detect a Kala Ilan forgery by exposing the overdyed layer more clearly when the blue temporarily disappears.

[37] https://hal.science/hal-05079453v1/file/AEGIS%2030_V5_2025-04-07_ISBN_Chapter%207.pdf

Only A Temporary Change - The Sample Quickly Reverts

The vat dyes in the wool become colorless, but only temporarily. On exposure to oxygen when removed from the urine test vat, Kala Ilan's overdyed fraudulent blue-purple color immediately returns and Murex based Techelet's true blue-purple completely returns as well.Therefore the urine test can be confusing to interpret, if the original dyeing is not uniform, the reaction is only partial or if the dye oxidizes back too quickly, the tester might misread the result.





Photos: Cochineal over indigo Kala Ilan; (Left) Turned red, shown immediately after removal from blank reduction vat. (Right) After oxidation it reverts to its previous appearance, Kala Ilan, the blue base color returned.

Test Two - Acidic Sourdough Bake

ורב אדא קמיה דרבא משמיה דרב עוירא אמר מייתי חמירא ארכסא דשערי ואפיא לה בגוויה אישתנאי למעליותא כשרה לגריעותא פסולה וסימניך שינוי שקר שינוי אמת

"Rav Adda said before Rava, quoting Rav Avira (Eretz Yisrael): One brings leavened barley sourdough and bakes the dyed wool within it. If the wool's color changes for the better, it is kosher; if it changes for the worse, it is invalid. The mnemonic given for this test outcome is: 'A false change [indicates forgery]; a true change [indicates authenticity].'"

The second test targets the mordant-based red overdyes. Mordant dyes, while generally stable under normal usage conditions, under moderate acidity combined with prolonged heat, will eventually break down[38] [39]. In contrast, true vat-based dyes such as indigo, woad, and Murex-derived dyes are resistant, stable, and can even improve under the same conditions.

Photo: Active Barley Sourdough Starter.

Barley Sourdough Starter Bake - Acid & Heat

Strongly fermented barley sourdough starter (*ḥamira arkesa d'sa'arei*), is naturally acidic[40] with lactic & acetic acids, often as low as pH 3.5[41]. Unlike wheat, barley contains less gluten but more nutrients and fermentable sugars, which feed lactic acid bacteria more effectively and therefore barley has higher LAB Lactic Acid Bacteria level compared to wheat sourdough[42]. This produces a faster, more robust lactic acid load and a sharper drop in pH, giving barley-based starters unusually high availability total titratable acidity (TTA)[43]. In addition, barley flour absorbs more water and ferments more rapidly because of its natural enzyme activity, further strengthening the acidic environment. When the starter is deliberately left overripe or overproofed, its acidity increases even more, ensuring the wool is exposed to maximum stress in the test.

Photo: (Top two yarn samples) Kala Ilan after baking in a Barley Sourdough Starter, the top one is cleaned from baked dough. (Bottom yarn) Kala Ilan, Madder overdyed on Indigo, control for comparison.

When wool samples are baked within this medium, the combination of sustained heat at 100°C and extended acidic steam exposure is sufficient to break down mordant-based dyes, exposing the blue base beneath.

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[38] https://www.mdpi.com/2079-6447/2/4/31, "Further addition of acid will result in the full protonation of the alizarin ligands and destruction of the complexes."
[39] https://botanicalcolors.com/mordant-monday-does-indigo-damage-mordants/, "I've found that citric acid can strip color from mordanted fibers and as you mentioned, it can damage the mordant bond."
[40] https://thesourdoughjourney.com/how-to-strengthen-a-weak-acidic-starter/
[41]https://www.researchgate.net/publication/282894689_The_Technological_Evaluation_of_Sourdoughs_Prepared_in_Different_Conditions
[42] https://pmc.ncbi.nlm.nih.gov/articles/PMC11311496/
[43] https://www.sciencedirect.com/science/article/pii/S0023643814004204

The outcomes of the second test are final and conclusive. If the color remains strong, improves, or deepens, showing stability under acidic heat, the sample is confirmed as kosher Murex Techelet. If the color permanently degrades, shifting towards a flat or weakened blue and losing its purple hue, it exposes the use of a mordant overdye forgery and the wool is invalid.

Permanent Change In The Test Sample - Shinui Emet or Shinui Sheker

Photo: Right yarn is Kala Ilan baked in Barley Sourdough Starter, turned more blue and lost purple hue, and the left yarn is unbaked Kala Ilan for comparison.

Unlike Test One, this second test yields irreversible results. The dye is permanently altered or destroyed, conclusively proving either authenticity or forgery. After conducting Test Two, Test One can no longer be performed effectively on a failed sample, as the dye structure itself has been permanently compromised and revealed as a fake.

True Murex Dyed Techelet Improves With Heat & Mild Acidic Environments

True murex dyes will improve with acidic heat becoming more vivid and darker. MBI shifts to a stable darker blue-violet color[44] and DBI becomes a more vivid red under heat[45], while the mild acidic environment stabilizes and improves vat dyes. A warm or hot vinegar bath is commonly used in indigo dyeing to finish and brighten colors[46], and the mild acidic effect of the sourdough bake similarly benefits the true murex dyed sample.

Photo: MBI shifts from red-violet to dark blue-violet under heat.[47]

The Crisis - Mar from Mashkhei

מר ממשכי אייתי תכלתא בשני רב אחאי בדקוה בדרב יצחק בריה דרב יהודה ואיפרד חזותיה בדרב אדא ואישתנאי למעליותא

"Mar from Mashkhei brought Techelet in the days of Rav Aḥai. They tested it with the method of Rav Yitzḥak bar Rav Yehuda (Test 1), and the color separated. Then they tested it using the method of Rav Adda (Test 2), and the color improved."

The Gemara records a rare case of confusion surrounding the two tests; Mar from Mashkei brought Techelet to Babel in the times of Rav Ahai. Both tests were done to this batch or individual sample of Techelet. Test 1 appeared to “separate its appearance”, and using Test 2 it improved, revealing a possible

[44] https://thelibrary.tekhelet.com/uploads/DOD%2038%20Ziderman%20v2.pdf
[45] https://www.mdpi.com/2571-9408/6/1/36
[46] https://blog.ellistextiles.com/2017/05/06/how-to-finish-indigo-and-a-natural-dye-book-in-the-works
[47] Thermochromicity in Wool Dyed with 6-Bromoindigo Dependson the Presence and Identity of a Solvent, https://www.researchgate.net/publication/367198868_Thermochromicity_in_Wool_Dyed_with_6-Bromoindigo_Depends_on_the_Presence_and_Identity_of_a_Solvent

critical flaw in the tests or the samples. The sample tested appeared to yield contradictory results and this case became a crisis.

We can assume Mar from Mashkei was a Chaver Mumche whose Techelet could be trusted. They likely knew the Techelet purchased from Mar was real so it was insisted on to do the second test when the first appeared to split.

The story forced a deeper look into the functional structure of the tests and more investigation was needed.

- How could the sample fail one test but pass the other?
- Was the sample even Techelet or Kala Ilan?

Rav Ahai's Halachic Framework

אמר להו רב אחאי **אלא הא לא תכילתא היא ולא קלא אילן היא? אלא** שמע מינה שמועתא אהדדי איתמר היכא דבדקנא בדרב יצחק בריה דרב יהודה לא איפרד חזותיה כשרה איפרד חזותיה בדקינן לה בדרב אדא בחמירא ארכסא אישתני למעליותא כשרה לגריעותא פסולה שלחו מתם שמועתא אהדדי איתמר

*"Rav Aḥai said to them: **What, is this neither Techelet nor Kala Ilan? Rather,** we must conclude that the teachings were transmitted together. If we tested it with Rav Yitzḥak bar Rav Yehuda's method (Test 1) and the color did not separate, it is kosher. If the color did separate, we then test it using Rav Adda's method (Test 2) with the sourdough. If the color changes for the better, it is kosher. If it changes for the worse, it is invalid. They sent from there (Eretz Yisrael): 'The teachings were transmitted together.'"*

Rav Aḥai clarified the conflict, it is not possible for a sample to be neither Techelet nor Kala Ilan, it must be one or the other, either Techelet or Kala Ilan. Additionally, the tests themselves are also valid on their own and not in conflict. Rather, in this case of doubt or a false positive with the first test, the second test resolves the doubt.

Marei Sheni Sheba - A Known Phenomenon

The phrase "איפרד חזותיה" shows that the sample color visually split or separated, which is interpreted as a sign of an underlying forgery. However, uneven dyeing and pigment streaking are common in authentic Murex-based Techelet;

- אפילו מראה שני שבה[48]
- גיזת צמר שצבעה תכלת ויש בה מקומות שלא עלה שם הצבע יפה[49]

Depending on vat conditions, saturation level, and artisan skill, even genuine murex dye can produce irregular coloration, color streaking or poor uptake in seemingly random places. The components of Murex Trunculus dye (IND, MBI, DBI, INR and more), have different molecule sizes and do not bind to the wool uniformly without a high level of dyeing experience and skill. Improperly prepared, oily, thick or twisted wool can further exaggerate the uneven distribution of pigments on the wool. It is entirely possible that the tester simply misinterpreted these natural dye colors running on the wool as a sign of forgery.

[48] Menachot 42b - רבי יוחנן בן דהבאי אומר אפילו מראה שני שבה כשר משום שנאמר (ויקרא יד, ד) ושני תולעת
[49] Berachot Rashi 9b

Additionally, although a common method among dyers, a urine vat reduction takes a level of skill and familiarity with the art of dyeing that an amateur or first time dyer will not always get right away. Weak, partial or no reduction with the urine vat method could be expected even from experienced dyers sometimes and surely with someone who never achieved a reduction of indigos otherwise, likely our ancient tester. A partial reduction would give the appearance of separation especially when combined with an uneven or lower quality murex sample as we just mentioned

Rav Ahai's Testing Protocol - שמועתא אהדדי איתמר

Rav Ahai realized there are cases where the urine test has limitations, therefore he set up a protocol which factors these in, to catch the false positives. Test one remains valid and the primary one, and if it passes, there is no need to proceed further. But due to the limitations of the reduction test and murex dyeing itself, it can sometimes be misinterpreted as a false positive. In those cases, the second test would be used to clarify.

Rav Aḥai doesn't discard the tests, he integrates them. Rav Aḥai's ruling reframes the contradiction and confirms that the two tests are not in conflict. Rather, they function as complementary parts of a single testing system. Test one reduces the vat dyes, while test two degrades mordant dyes and clarifies the false positives of the urine test.

Why Continue To Use Test One If Test Two Is Conclusive?

Rav Ahai, realized by not including the first test we would miss crucial information on the nature of Kala Ilan and its recipe of a blue vat dye overdyed with a red mordant dye. The first test transmits unique information and tests for something different than test two does. Nullifying the urine test in favor of the sourdough test alone would also give the idea that Chazal's first test was somehow flawed, when in actuality the flaw was either with a lower quality Murex dyeing or an error interpreting the results. The test works and its functionality is still valid in most situations.

Photo: Madder dyed yarn after simmering 100C in pH 3.8 Lactic Acid solution for 30 minutes.

Did Mar from Mashkei's Conflicted Test Result Really Split?

Did the sample in question actually split colors in the urine test and then improve in the sourdough test? Taken literally, that would be impossible and this is inherent in Rav Ahai's response. Both Kala Ilan and Techelet have specific expected behaviors under the tests. Kala Ilan separates under Test One and ruins under Test Two. Techelet remains one color in Test One and improves under Test Two.

There is not a third option. Therefore Rav Ahai exclaims, "What, is (it possible) this is not Techelet and not Kala Ilan?", meaning, there is no third option, there was a misreading in test one. His point is that such an outcome cannot exist in reality. If the wool improved under Test Two, it must have been genuine Techelet all along. The supposed "split" in Test One was not a true reaction but a misreading whether due to uneven dyeing, weak reduction, or the natural irregularities of the vat.

Why Didn't Rav Ahai Mention The Tests Reversed Too?

Could the sourdough test be done without the urine test first? Yes of course, the second test on its own would disqualify or permit a sample as it did for a generation until the dual testing of Mar from Mashkei's Techelet. But Rav Ahai didn't mention the tests in the reverse order, sourdough first and then urine, because the sourdough bake will permanently affect the sample and the first test can never vindicate it. In other words, the second test's identification of an imitation cannot be salvaged by the urine test.

The Test Compliment Each Other, Not Contradictory

Rav Aḥai thus resolved the crisis showing that the two tests were never in conflict, they actually complement each other by exposing a different ingredient in the imitation. While the second test can also vindicate false positives of the first test, creating the halachic framework still fully functionable today. We can now confirm the accuracy of the system.

כדרך שהצבעין עושין – The Way of the Dyers

Modern Techelet production commonly uses contemporary chemical agents such as hydrosulfite and dithionite. These achieve the same chemical reduction effects as the ancient fermentation-based reduction methods used by dyers in antiquity, albeit in a much stronger and more effective way. The principle of *כדרך שהצבעין עושין*, as explained by Rashi and Rambam, permits such practical and chemical equivalence in dyeing procedures if needed. If a process achieves the same functional result as the original method, it is halachically valid.[50]

This principle also applies to the Gemara's dye tests. We can use modern chemicals to replicate the functional outcome of each test exactly, without requiring the identical ancient ingredients. What matters is the chemical effect, not the precise source material.

Clarifying the Purpose of the Two Tests Through Modern Dye Science

Armed with ancient imitation dye recipes, modern dye chemistry explains exactly how the tests work. Once the functionality is understood, we can apply the same dye chemical principles to achieve the results chemically or to determine the functional ratios of the ingredients given by Rashi and Rambam, even when their exact measures are not preserved. This can let us reproduce the intended outcome precisely, using the same principles that Chazal relied upon, but with modern control and efficiency.

The Tests Can Work With Both Rashi's and Rambam's Recipes

When understood through modern dye science, both Rashi's and Rambam's ingredient lists make complete sense. Each set of ingredients is simply a different way to achieve the same goal, improving fermentation in the aged urine to create a reliable alkaline reduction that will temporarily hide the blue vat dye and reveal any hidden red mordant overdye.

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[50] Rambam, Laws of Tzitzit 2:2 - "כֵּיצַד צוֹבְעִין תְּכֵלֶת שֶׁל צִיצִית. לוֹקְחִין הַצֶּמֶר וְשׁוֹרִין אוֹתוֹ בְּסִיד וְאַחַר כָּךְ מְכַבְּסִין אוֹתוֹ עַד שֶׁיִּהְיֶה נָקִי וּמַרְתִּיחִים אוֹתוֹ בְּאֶהָלָא וְכַיּוֹצֵא בּוֹ כְּדֶרֶךְ שֶׁהַצַּבָּעִין עוֹשִׂין כְּדֵי שֶׁיִּקְלֹט אֶת הָעֵיִן". Rashi similarly, "- וסממנים עד שיהיה נקי ומרתיחים אותו באהלא וכיוצא בו כדרך שהצבעים עושין כדי שיקלוט את העין:"

By applying this understanding, we can now set accurate, practical ratios for either recipe. The dual recipes from Rashi and Rambam achieving the same function not only clarify Chazal's original intent but also gives a chemically sound, halachically valid standard for performing and interpreting the tests today.

Rashi's Formula - Alum, Fenugreek Water, and Aged Urine

- Aged Urine: The core alkaline base that reduces the blue vat dye into its colorless leuco state.
- Fenugreek Water: Just a small amount acts as a fermentation accelerator, boosting enzymatic activity and ensuring the reaction completes in the overnight timeframe.
- Alum: Used only in tiny amounts, not for reduction (since it is acidic and would hinder reduction if overused), but to brighten and stabilize any mordant red dye so it becomes more visible when the blue is temporarily removed.

Rambam's Formula - Aged Urine, Straw, and Snail Slime

- Aged Urine: Provides the alkaline reducing environment.
- Straw: Feeds bacterial fermentation, fueling a quick and efficient reduction process.
- Snail Slime: Likely contributes natural enzymes or microbes that further enhance and accelerate red uction, ensuring clear results.

Modern Chemical Blank Reduction Vat

- Warm solution in the indigo reduction window, about 45C - 55C.
- Alkalinity in the indigo reduction window, about pH 9-10.5.
- Reduction catalyst like Sodium Hydrosulphite or Dithionite.

Conclusion - The Sugya's Logic Only Works with the Authentic Techelet & Forgery Color

Everything in this sugya, both tests, their outcomes, Mar from Mashkei's case, and the use of the second test to vindicate false positives in the first, depends on one thing, that Kala Ilan behaves differently from Techelet. Not only that they both behave differently, but further, that the imitation is made from a blue vat dye and red/violet mordant dye overdyeing, and the true Techelet is Murex Trunculus based Blue-Purple. If both Kala Ilan and Techelet were simply both indigotin or pure blue or plain indigo blue, they would both react to the tests identically. There would never be a *Shinui Emet* or Shinui Sheker moment, Mar's dilemma could never happen, and the sugya itself loses all coherence.

This means the sugya itself rejects the "pure blue theory". The tests were preserved because they worked, and they still work, but only when applied to the *correct* Techelet color and forgery recipe model, Blue-purple Murex Techelet imitated by a Blue-purple overdyed Kala Ilan. The two tests Chazal gave for detecting Kala Ilan are not relics of the past, they still work exactly as intended.

Chapter 4 - QA

Q: Is pure blue kosher for Techelet?

A: Pure blue murex does not match the historical record for the royal dye itself or its imitations. Pure blue indigotin derived from degraded Murex snail dye does not qualify as a unique and testable dye as required by the Talmud and Rambam[51]. Wearing pure blue *as a placeholder for true Techelet* does not fulfill the mitzvah of Techelet which we've proven is not simply blue or any other color range than blue-purple, even from the correct source.

Q: Is pure blue from Murex considered Kala Ilan?

A: Kala Ilan historically is an imitation of Blue-purple Techelet using one of the overdye methods to alter the appearance of plant blues to appear blue-purple using a red or violet overdye.

Whereas pure blue from Murex only imitates the base ingredient in the imitations by degrading the snail dye via full UV debromination to look like the plant blues, woad or indigo. Pure blue from Murex would then simply be considered a dye colorant (Tzeva) which would be permitted as one of the "white strings" but obviously not as Techelet or even a placeholder for true Techelet.

The Sifre called out someone who puts **any other colorants intentionally** on their talit and declares those colored strings as Techelet, not just with Kala Ilan which resembles Techelet.

Q: Isn't any blue from Murex good enough?

A: No. Only a specific blue-purple range will allow the tests to work. If true murex dye is degraded through full debromination to pure blue, it no longer carries the sign of true Murex Trunculus based Techelet dye, a visibly purplish brominated profile and appearance.

The tests won't function and it will not match historical Murex artifacts or dyeing methods.

Photo: Murex Trunculus dyed Techelet in the authentic deep, dark blue-purple hue.

Q: What about blue Murex tzitzit with trace but invisible bromides or minimal visible violet?

A: Trace amounts of MBI or DBI detected only in a lab do not mean the test will function. If the visible violet or purple level in wool dyed with true Hilazon dye, would force an indigo based imitation to add a red overdye to match it, then it probably falls in the correct range of hue for authentic Murex Trunculus Techelet, saturation or shade aside. But if the original murex is degraded so much that it is visibly pure blue and it can easily be confused with pure plant blue indigo, then it wouldn't be categorized historically as Techelet. The Gemara's tests are visual and practical, not analytical chemistry on the molecular level. The tests are based on what is visible to the human eyes, not hidden chemical traces.

[51] Rabbi Shlomo Miller of Toronto Kollel, Moetzes Gedolei HaTorah, "ואין שום חילוק ביניהם באופן כימי ועל כן אי אפשר להיות שום בדיקה להבחין ביניהם"

Q: I've heard that there is nothing to lose by wearing the pure blue murex even if it's wrong, is this true?

A: If the dye or color is not *Techelet* under the Gemara's testing scenario and criteria, the wearer is not fulfilling the mitzvah of Techelet at all, at best they are simply wearing plant-blue colored "white strings". Instead of bringing the mitzvah back, it entrenches a substitute in its place. Halacha is about searching for the Emet, not a free pass to be wrong.

Q: Is any dyed color from the chilazon, Techelet?

A: The Gemara gives tests that only work in the blue-purple color range. Only blue-purple would qualify historically, scientifically and halachically as Techelet based on the points brought in this book. While violet, red-violet and even greenish-blues can also be achieved with Murex Trunculus by known dyeing or chemical methods, those specific colors would not qualify as reacting to the tests appropriately to be deemed in the true Techelet color range. In other words, the only way to be defined as Techelet according to the Talmud's sugya on the tests of Kala Ilan, it would have to be in the blue-purple range.

Q: What happens to Radzyner Cuttlefish based, Prussian Blue strings in the blank reduction vat?

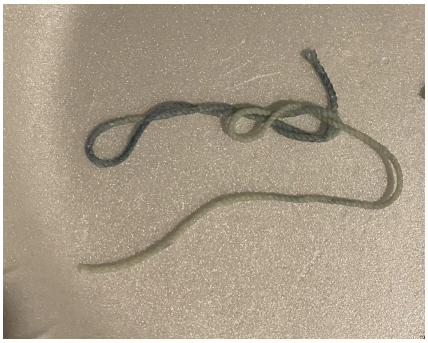


Photo: Radzyner Prussian Blue string after soaking in a blank reduction vat.

A: While not colorsafe to washing or rubbing, Prussian blue on wool also changes from blue to colorless upon reduction, becoming Prussian White[52]. When I placed Radzyner strings in a blank reduction vat it turned mostly colorless and mostly came back to blue when removed from the vat. Therefore, Radzyner Techelet is not only not colorfast, it would additionally fail the testing scenarios of the Talmud.

Q: Don't we have a mesorah that Techelet is just any blue?

A: There is no unbroken mesorah for the exact hue of Techelet. Rambam says the exact blue of Techelet was not possible in his times, this would exclude Indigoferra & Isatis Indigo blues. Additionally, we cannot lock in prior estimations when new or clarifying evidence emerges.

Q: But doesn't Rabbi Meir say Techelet is like the sea and the rakia?

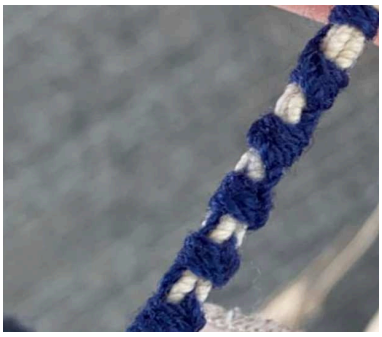
A: Yes. In Chazal's language, "rakia" was not pale daytime sky blue but a deep, dark blue-violet night sky, like the clear heavens seen through the atmosphere in the middle of the sky at midnight. Reducing the metaphor to a single modern indigotin blue definition or shade ignores both context and intent.

Q: Techelet is a natural dye and natural dyes are known to have some variability in outcomes. Isn't it natural that sometimes it will come out pure blue?

[52] https://en.wikipedia.org/wiki/Prussian_blue, https://resources.culturalheritage.org/anagpic-student-papers/wp-content/uploads/sites/11/2016/01/2015ANAGPIC_-Zweifel_paper.pdf

A: Techelet is in the range of hues and shades in the Blue-purple spectrum. While natural dyes can vary in hue, shade or depth, they do not jump across fundamental color categories when processed with standardized recipes. The Gemara's tests only function within the blue-purple range that is the defining mark of Techelet. If the dye comes out as pure blue, it indicates that the purple component of the Hilazon pigment has been degraded or lost, usually through debromination, and all that is left is the indigotin. That result may produce a colorant, but it no longer qualifies as Techelet halachically or historically.

Photo: Deep Blue-purple Techelet from Murex Trunculus.



Q: I've heard the Gemara says there is no test for Techelet and Kala Ilan?

A: The Gemara is very clear, after proposing the idea of testing, that there are tests for Kala Ilan. After explaining the tests and how they worked, the Gemara clarifies its statement of אין לה בדיקה "there's no test", that it means there's no test to know if the vat was used for testing or if the vat is Maareh Sheni. מאי אין לה בדיקה נמי דקאמר אטעימה. There is no test for a Maarei Sheni or a test vat, but there are two tests for Kala Ilan.

Q: I've heard that the modern blue Techelet has passed the tests of the Gemara. Is that possible?

Photo: Pure blue yarn from snails (top) and pure blue from plants (bottom) completely reduce to colorless in a blank reduction vat.

A: Pure blue could never pass the tests as described by Chazal, being the very same molecule it doesn't qualify as a testable color scenario against its assumed imitation, plant indigotin.

Additionally, based on the theory that Techelet is only pure blue indigotin, *Ipared Chazuteh* in the first test cannot mean the color profile split, because there is only a single pigment. It would have to mean fading in the pure blue theory, and that very same outcome of "fading" via reduction in the first test automatically disqualifies both pure blue samples, whether from plant indigo or from Murex. And in the second test, they would yield identical results, since they are chemically the same molecule, indigotin is color-safe in mild acidic conditions at 100C. On that basis alone, pure blue can never be the Techelet of the Gemara.

Q: MBI, one of the pigments in Techelet, when dyed on wool shifts from red-violet to blue-violet under heat. Is this proof that Techelet was really pure blue from the Murex Trunculus?

A: Techelet was never a single-pigment dye but a complex mixture of indigotin (IND), monobromoindigo (MBI), and dibromoindigo (DBI)[53]. No sample of Murex dye has ever been found that was 100% MBI.

Additionally, while MBI does shift under heat from red-violet to a dark blue-violet[54], the saturated colorant on wool always appears deep, dark blue-violet, never pure blue or sky blue. Thus, the heat behavior of MBI confirms Techelet's purple-blue character, not a reduction to sky-blue.

[53] https://www.tekhelet.com/pdf/TheBiblicalDyeTekheletanditsUseinJewishTextiles.%20Reprint.pdf
[54] https://thelibrary.tekhelet.com/uploads/DOD%2038%20Ziderman%20v2.pdf

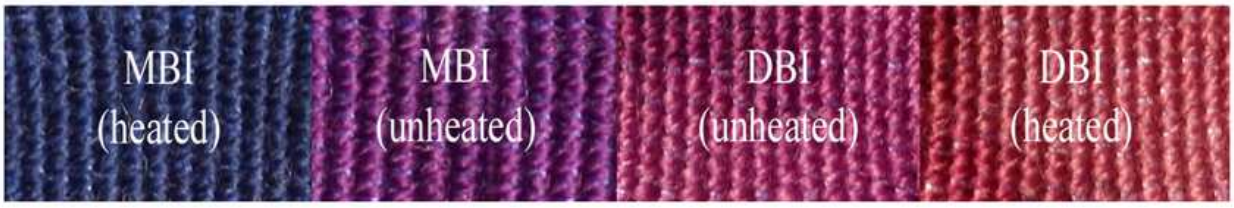


Photo: MBI & DBI are affected by heat, MBI becomes Blue-purple while DBI becomes more Red.[55]

Q: If Techelet is Blue-purple and not pure blue, what was Argaman?

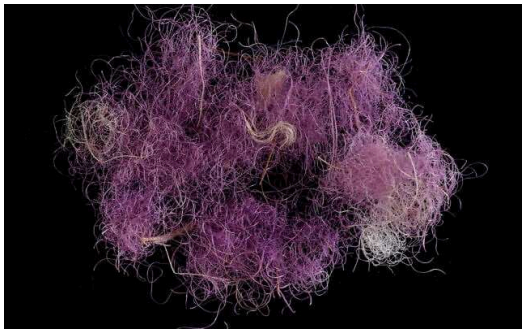


Photo: Snail dyed Argaman wool found in the Timna Valley.[56]

A: Argaman was a DBI dominant Red-purple commonly known as Tyrian Purple, made with the Brandaris & Haemastoma snails known for their high DBI profile. Both Techelet & Argaman were famous dyes known for their purple color range, Techelet is Blue purple while Argaman is Red purple.

Q: The Wadi Murabbaʿat textile appears faded dark greenish-blue. Doesn't that mean ancient Techelet was light or sky-blue?

A: The appearance of the Wadi fragment today can be misleading. The wool has oxidized and yellowed after nearly two millennia, and the soil patina further mutes the color. When a yellowed substrate combines optically with any bluish pigment, the human eye perceives a **greenish-blue** tone. This is a surface-aging effect, not the original hue of the dye.

Photo: Wad Mubara'at Murex Trunculus dyed fragment.

Chemically the laboratory analyses tell a different story. Published HPLC data shows the pigment mixture as; Indigotin (IND) = 52 %, Monobromoindigo (MBI) = 38 %, Dibromoindigo (DBI) = 10 %.

This profile should create a blue-purple color in the freshly dyed state. Even the greenish cast now visible supports this. In subtractive color terms, a greenish-blue arises when a bluish dye is viewed through a yellowed medium.

Q: Doesn't the Gemara in Bava Kamma 93b say that Kala Ilan cannot be removed with *tzapon* (soap)? Doesn't that prove Kala Ilan is just indigo and not a mix with other dyes like madder, kermes or orchil? Would that mean that the true Techelet was not colorsafe to soap?

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[55] Thermochromicity in Wool Dyed with 6-Bromoindigo Depends on the Presence and Identity of a Solvent, https://www.researchgate.net/publication/367198868_Thermochromicity_in_Wool_Dyed_with_6-Bromoindigo_Depends_on_the_Presence_and_Identity_of_a_Solvent

[56] Photo, Israel Antiquities Authority

A: The sugya in Bava Kamma is not identifying Techelet or Kala Ilan, it is ruling on whether dyeing counts as a *shinui* (permanent transformation) in the case of stolen wool. *Tzapon* is cited as a cleaning agent and if a dye can be removed with it, the wool reverts to its prior state and no *shinui* occurs and if it cannot, the change is permanent. Kala Ilan is mentioned simply because it was a common soap-fast dye in the marketplace that resisted washing.

The Meiri rules[57] that any dye which cannot be fully removed is considered permanent in regards to shinui and ownership, the Gra also clarifies[58] that we are not specifically referring to Kala Ilan here, rather any dye that holds up to washing with soap. In practice, Techelet is more colorfast than Kala Ilan[59], and many natural dyes (indigo, madder, kermes, orchil) also withstand washing with soap. The Gemara's point is not to identify Kala Ilan with a specific dye, but to establish the principle that any enduring dye creates a permanent transformation to affect ownership.

Additionally, Techelet was clearly colorfast to washing as shown in Zevachim 95a, that the Meil was laundered and blood stains were removed, but not the extremely colorfast Techelet dye.[60]

[57] Meiri on Bava Kamma 93b - *כגון שצבעו בקלא אילן או כיוצא בו בצבעים שאין יכול להעבירם*
[58] Beur HaGra on Shulchan Arukh, Choshen Mishpat 360 - *אפי׳ בסתם צבע שלא בקלא אילן*
[59] Menachot 42b
[60] Zevachim 95a - אָמַר רֵישׁ לָקִישׁ: מְעִיל שֶׁנִּיטְמָא – מַכְנִיסוֹ בְּפָחוֹת מִשָּׁלֹשׁ עַל שָׁלֹשׁ **וּמְכַבְּסוֹ**, מִשּׁוּם שֶׁנֶּאֱמַר: ״לֹא יִקָּרֵעַ״.