Selective silicones in ethanol-based sanitisers

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Abstract

Isotropic crystal-clear phases are formed by incorporation of PEG-12 Dimethicone, PEG/PPG-18/18 Dimethicone and PEG-10 Dimethicone, in defined areas on different phase diagrams of carbomer 940/ triisopropanolamine/ water/ ethanol/ silicone copolyols. Other selected silicone ingredients were also screened to check for formulation clarity and sensory benefits. At the end formulation space and several unique combinations of copolyol/gum blends are proposed to yield optimised performance. The leading hand sanitisers thus developed have no need to use glycerin or propylene glycol. They provide smooth, moisturising, non-tacky, silky hand after-feels. This technology contributes to world consumer needs in seeking better hand sanitisers to combat COVID-19 and other contact-transmission diseases.

Hand cleansing and sanitisation are key steps to prevent diseases caused by contact-transmission of microbials. With COVID-19 global pandemic, various hand sanitisation products are in high demand. The dominant products are ethanol-based hand sanitisers. They are widely used to fight the pandemic, in liquid or gel forms. However, ethanol-based hand sanitisers irritate and defat skin and have sticky after-feel when not optimised. Alcohol topical usage has been controversial.[1-2] Glycerin and propylene glycol (PG) can be added into a hand sanitiser to partially mitigate the dryness but impart unpleasant tackiness hand after-feels. Such tackiness is much more pronounced in gel form. The unmet consumer needs prompted the development of an improved hand sanitiser gel system for superior hand after-feels.

A variety of silicones are selected with dominantly silicone copolyols, to replace glycerin and/or PG, in combination with carbomer 940/ triisopropanolamine (Carbomer/TIPA) primary gelling system, to form aquo-alcohol based hand sanitising gels. As arbitrary addition of silicones followed by trial-and-error practice is never the most efficient where phase boundary may exist, this leads to the approach to build the formulation system "ground up" in order to achieve the end results while learning phase information at same time.

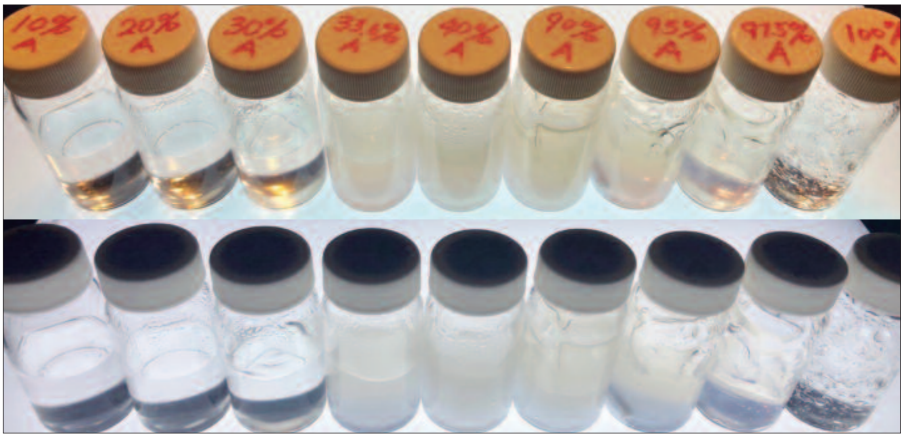

Figure 1: A sequential dilution of SDA 40B with A gel (from left to right): (1) 10% A as a thin fluid; (2) 20% A as fluid; (3)30% A as a shear thinning flowable clear gel; (4) 33.6% shear thinning flowable translucent gel; (5) 40% to 95% A as a thick translucent gels; (6)97.5% A as haze clear gel; (7)100% A as a clear gel.

Seeking clear effective base gels

Carbomers are poly(acrylic acid) which can be neutralised to form effective aqueous gels at extremely low concentration. Although simple inorganic bases can be used for neutralisation, organic bases frequently deliver a wider clarity range when ethanol or solvents are used. As Carbomer 940 is widely available, it has been selected for this study. Other carbomers can easily replace it for similar results. Among different organic bases, Triisopropanolamine (TIPA) is selected to neutralise Carbomer 940 in search for clear hand sanitiser gels. Other organic bases like Diethanolamine (DEA) is also a pretty good choice.[9]

Carbomer 940 is a fluffy white powder and TIPA a chunky solid at room temperature. To study the equivalent point, these ingredients are diluted into 1% and 10% respectively in water then titrated each other. In both cases it shows 1: 0.775 (w/w) ratio with end pH from 6.0. pH 7 has not been explored to leave room for production adjustment as needed. At this ratio mother loads of 1% and 10% clear pre-gels called gel A and gel B are being prepared for subsequent study. Pre-gel is a great approach to save time and material because forming a homogeneous thick gel is most time consuming while gel dilution is relatively easy. Both gel A and B are highly viscoelastic ring gels. A sturdy mechanic stirrer is recommended to provide rigorous stirring. Due to the gelatin-like texture of the pre-gels a homogeniser is not an option in the pre-gel making process. However, a homogeniser is the fastest tool for gel dilution. In this study, only a few seconds is required to complete gel dilution at high rpm.

The phase behaviours of gel A and B in mixing with ethanol are highly dependent on the quality and type of the commercial product. For example, a cloudy gel region was observed from (33.3 % gel A: 66.7% SDA 40B) to (97.5% gel A: 2.5% SDA 40B) when SDA 40B is used as diluent, as shown in Figure 1.

However, when alcohol changed to a food grade 100% ethanol, the above cloudy region disappeared to give a complete

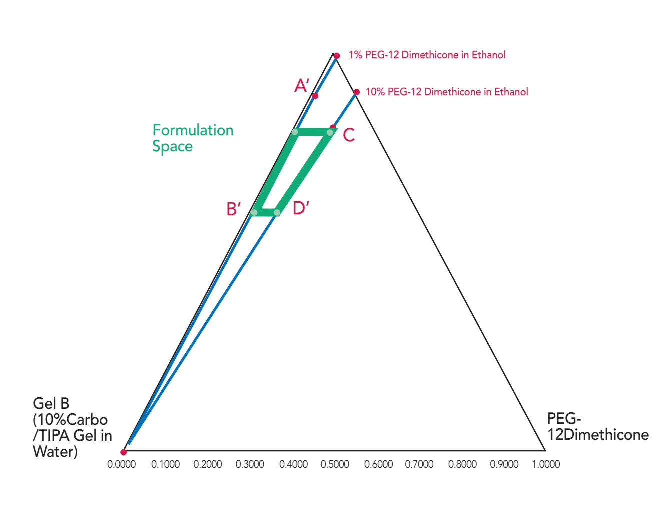

Figure 2: Pseudo-tertiary phase diagram of Ethanol/PEG-12 Dimethicone (BRB 526)/Gel B(10% Carbomer 940/Triisopropanolamine 1: 0.775 w/w). A', B', C', and D' are all isotropic system points.

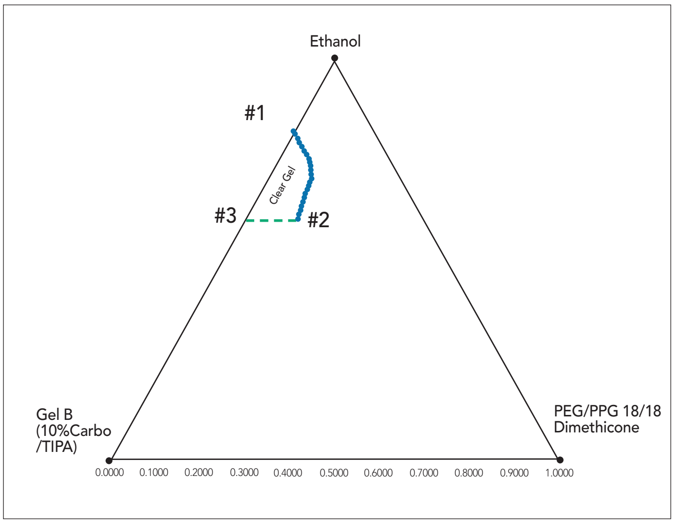

Figure 3: Pseudo-tertiary phase diagram of Ethanol/PEG/PPG-18/18 Dimethicone (BRB 523)/Gel B(10% Carbomer 940/Triisopropanolamine 1: 0.775 w/w).

crystal-clear mixture in any ratio. Thus, it is speculated that the denaturing agent or trace impurity in SDA 40B may have caused such cloudiness. During COVID-19, the alcohol world market is somewhat chaotic to say the least. Different players offer different qualities. It is strongly recommended that formulators in this area conduct similar screening experiment to check the quality of reagents before further experiment and production. Checking at this stage would be wise and could save a lot before going deeper into R&D and production cycles.

From the above pseudo-binary mixing, the first non-silicone simple clear hand sanitiser base #1 is obtained. It has a composition of (70% ethanol, 29.7% water, 0.17% carbomer 940, and 0.13% TIPA) with 3000 mPa·S in viscosity. This satisfies WHO's hand rub ethanol regulation of minimum 60% ethanol. It also preserves room for benefit agents. Base #1 is a relatively weak gel which liquifies quickly on hands. So, a higher gel strength is being studied.

With 10 times more gelling agents in gel B a stronger gel can be built. Using a similar method, Base #2 is a clear gel with much higher ethanol level. In the personal care industry, the upper non-irritation limit for TIPA was 1.1%.[2] The formulation made from 10% gel B has 0.44% TIPA content and therefore is safe. Base #2 exhibits enhanced viscosity and total clarity with the composition of (90% ethanol, 9% water, 0.56% Carbomer 940, and 0.44% TIPA). Further other benefit agents and water can be added in base #2 later. Also, combination of base #1 and #2 allows continuous gel strength adjustment when other ingredients are added. Such a wide formulation space of aquo-ethanol hand sanitiser gives total optical clarity and allows further exploration on silicone effects below.

PEG-12 Dimethicone in hand sanitiser gel

In this section the impact of PEG-12 Dimethicone (BRB 526, HLB 13) is investigated on moving the phase boundary of isotropic gel region in the diagram. Two techniques, i.e., pseudo-binary and pseudo-tertiary mixing, are efficient tools to explore phase diagrams of (gel A or B)/ethanol/PEG-12 Dimethicone.

For the pseudo-binary mixing, 1% and 10% PEG-12 Dimethicone in ethanol as two stock solutions are prepared on one end. On the other end either gel A or gel B is available. With a high-quality ethanol, phase points in the diagram of (gel

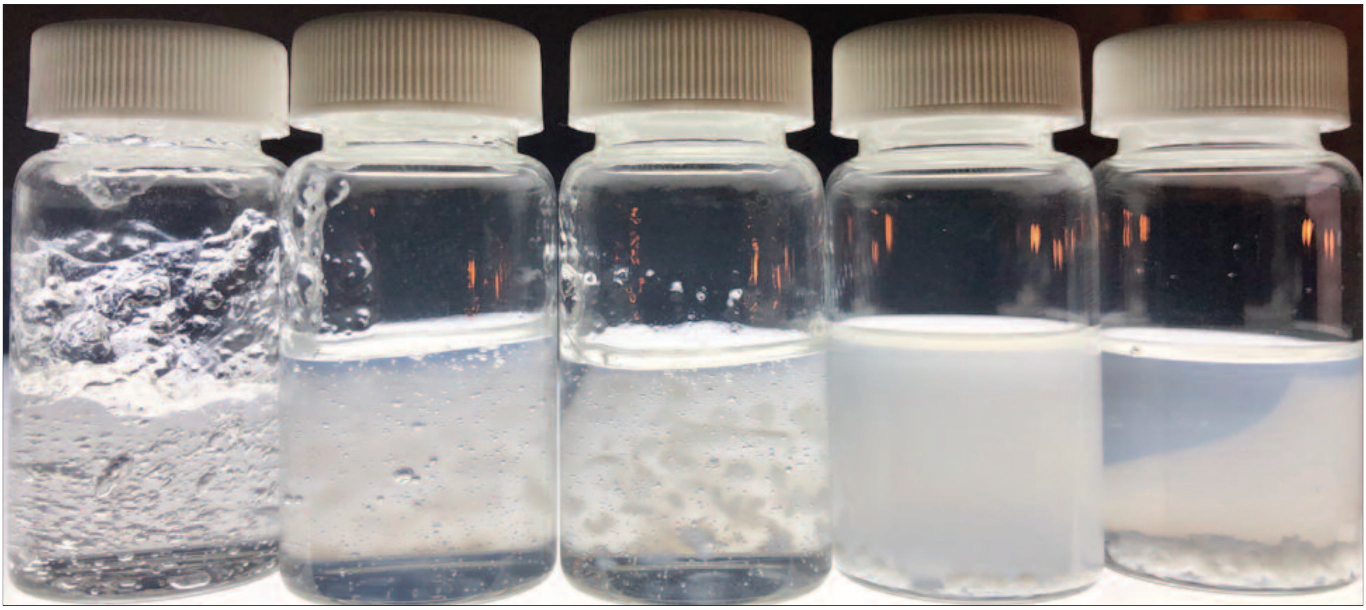

Figure 4: Examples of different phase behaviours. Left to right – clear gel, translucent gel, gel with minor phase separation, complete phase separation into liquid and precipitation.

A/ethanol/PEG-12 Dimethicone) have been sufficiently checked to convince that the whole phase diagram is completely isotropic. In the lower gel level an obvious phase boundary is not encountered.

The pseudo-tertiary diagram of (gel B/ethanol/PEG-12 Dimethicone) is more complex due to 10 times more gelling content. The system points with ethanol < 60% are so viscous and cause mixing difficulty. For all practical purpose with WHO's regulation of ethanol must be >60%, so ethanol levels between 60% to 80% are being focused.

Two binary dilutions confirmed practical formulation space in the diagram as in Figure 2. Although in theory one can go as high as 40% in PEG-12 Dimethicone, a 2-10% is considered to be a reasonable range to show cost-sensitive benefits. The green box in Figure 2, therefore, is an effective formulation space but not exclusive where clear gels could be obtained. Exploration outside the box definitely has academic merit.

PEG/PPG-18/18 Dimethicone in hand sanitiser gel

In comparison to a rather easy case in PEG-12 Dimethicone work, PPG moiety in the molecule causes the HLB to drop to 8. It is expected to have somewhat narrower clear phase region which turned out to be true.

In Figure 3, one can add as high as 82% ethanol (point #1) to gel B without triggering phase separation. To incorporate PEG/PPG-18/18 Dimethicone, which is more hydrophilic than ethanol, one needs to reduce ethanol and increase water content. It is seen that the clear gel phase boundary moves along the curve from point #1 to point #2 where the composition has (60% ethanol, 12% PEG/PPG-18/18 Dimethicone, and 28% water). All the system points on the left side of the curve are clear gels and the ones on the right likely have multiple phases may experience sudden drop in viscosity with white precipitations (Fig 4).

A pseudo-tertiary phase diagram has two degrees of freedom which means a system point can be converted into (X, Y) coordinates for plotting. Anyone can use the following techniques in an Excel sheet to plot a good phase diagram without need to purchase special tools or spend time hand plotting using following equations (1) to (3):

(1) $$X = \frac{Y}{3^{0.5}} + \textit{right component\%}$$

(2) $$Y = 3^{0.5} * \textit{top component\%}$$

In Figure 3, the right component is PEG/PPG-18/18 Dimethicone. The top component is ethanol. The left component is not independent due to mass balance equation:

(3) $$\textit{Right component\%} + \textit{Left component\%} + \textit{Top component\%} = 100\%$$

The coordinates and %composition and breakdown are summarized in Table 1.

Prior to gel B work, system points are checked for the gel A diagram (gel A/ethanol/PEG/PPG-18/18 Dimethicone). They are thin clear solutions due to low gelling agent load. With this knowledge on gel A and B on PEG/PPG- 18/18 Dimethicone, it is rather easy to freely adjust the composition to formulate the right ethanol base hand sanitiser gel.

The gelling agent levels in Table 1 are in excess. One can easily reduce them by dilution with 60-80% ethanol solutions without imparting phase transition. Due to the limit of this paper, this content has been omitted. Please also note that phase boundary of a thick gel is hard to study due to insufficient mixing in a small vial. Sometimes it is found that a translucent gel turns clear after several days or the 'galaxy' type of flocculation disappeared. For high quality work, larger scale work and a stability study may be needed to confirm. The phase boundary on Figure 3 may move slightly to the right depending on observation length.

PEG-10 Dimethicone also has its own characteristic phase diagram in hand

Table 1: Two dimensional coordinates and composition of system points in the pseudo-tertiary phase diagram of (Gel B/ethanol/PEG/PPG-18/18 Dimethicone).

Phase Point	X	Y	Gel B (10%) Carbomer /TIPA)	Carbomer 940	TIPA	Water	Ethanol	PEG/PPG 18/18 Dimethicone
Ethanol	0.5000	0.8660254	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%
10% Carbo /TIPA in Water	0.0000	0	100.00%	5.63%	4.37%	90.00%	0.00%	0.00%
BRB 526	1.0000	0	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Clear Gel	0.4100	0.7101408	18.00%	1.01%	0.79%	16.20%	82.00%	0.00%
Clear Gel	0.4150	0.7014806	18.00%	1.01%	0.79%	16.20%	81.00%	1.00%
Clear Gel	0.4200	0.6928203	18.00%	1.01%	0.79%	16.20%	80.00%	2.00%
Clear Gel	0.4250	0.6841601	18.00%	1.01%	0.79%	16.20%	79.00%	3.00%
Clear Gel	0.4300	0.6754998	18.00%	1.01%	0.79%	16.20%	78.00%	4.00%
Clear Gel	0.4340	0.6668396	18.00%	1.02%	0.79%	16.20%	77.00%	4.90%
Clear Gel	0.4400	0.6581793	18.10%	1.02%	0.79%	16.09%	76.00%	6.00%
Clear Gel	0.4450	0.6495191	18.00%	1.01%	0.79%	16.20%	74.00%	7.00%
Clear Gel	0.4490	0.6408588	18.10%	1.02%	0.79%	16.29%	73.00%	7.90%
Clear Gel	0.4500	0.6321985	18.50%	1.04%	0.81%	16.65%	72.00%	8.50%
Clear Gel	0.4500	0.6235383	19.00%	1.07%	0.83%	17.10%	71.00%	9.00%
Clear Gel	0.4500	0.614878	19.50%	1.10%	0.85%	17.55%	70.00%	9.50%
Clear Gel	0.4500	0.6062178	20.00%	1.13%	0.87%	18.00%	69.00%	10.00%
Clear Gel	0.4470	0.5975575	20.80%	1.17%	0.91%	18.72%	68.00%	10.20%
Clear Gel	0.4440	0.5888973	21.60%	1.22%	0.94%	19.44%	67.00%	10.40%
Clear Gel	0.4410	0.580237	22.40%	1.26%	0.98%	20.16%	66.00%	10.60%
Clear Gel	0.4380	0.5715768	23.20%	1.31%	1.01%	20.88%	65.00%	10.80%
Clear Gel	0.4350	0.5629165	24.00%	1.35%	1.05%	21.60%	64.00%	11.00%
Clear Gel	0.4320	0.5542563	24.80%	1.40%	1.08%	22.32%	63.00%	11.20%
Clear Gel	0.4290	0.545596	25.60%	1.44%	1.12%	23.04%	62.00%	11.40%
Clear Gel	0.4260	0.5369358	26.40%	1.49%	1.15%	23.76%	61.00%	11.60%
Clear Gel	0.4230	0.5282755	27.20%	1.53%	1.19%	24.48%	60.00%	11.80%
Clear Gel	0.4200	0.5196152	28.00%	1.58%	1.22%	25.20%	80.00%	12.00%
Translucent Gel	0.4500	0.6928203	15.00%	0.85%	0.65%	13.50%	60.00%	5.00%
Gel with "Galaxy lump"	0.5000	0.5196152	20.00%	1.13%	0.87%	18.00%	80.00%	20.00%
Predpitation/ Liquid	0.5000	0.6928203	100.00%	0.56%	0.44%	9.00%	80.00%	10.00%

Figure 5: BRB Clear Hand Sanitization Gels containing 2% of: (E") PEG-12 Dimethicone; (G') Blank; (H') PEG-10 Dimethicone; (I') PEG/PPG-18/18 Dimethicone; (O') PG/Glycerin.

sanitiser work. This is omitted for same reason for more practical content.

pH dependency of gelling behaviour is not explored as well. As carbomers are neutralised it is always an equilibrium distribution of unnaturalised acid and fully neutralised salt form in which pH definitely moves system behaviour.

Several hand sanitisers with and without silicone copolyols on fragrance load are being checked. It is found that at least at 1% net fragrance load, all clear gels remains clear without any cloudiness or precipitation.

Further screenings and formulations

Detailed work from the above two silicone copolyols sets concrete foundations for screening all silicones that have been selected. In the first run, more copolyols have been included: Cetyl PEG/PPG-10/1 Dimethicone and PEG-10 dimethicone. The silicones concentration is being locked at 2% and the ethanol level at 70% for the ease of single variable comparisons. The formulation compositions are summarised in Table 2 and the selected gels are shown in Figure 5.

From experience, it is known that with Trimethylsiloxysilicate (TMS), BRB 1860 (proprietary D5-free gum blend), BRB DM 55 (proprietary D5 replacement), BRB DM 66 (proprietary D5/D6 blend replacement) it is impossible to form completely clear gels but it is checked whether they have other merits such as sensory benefits.

Gels made from BRB 1860, BRB DM 55 and BRB DM 66 are translucent. This therefore offered some blending opportunity to be sought in the following section. A blank and a glycerin/PG formulation are being inserted as sensory controls in the following section.

Today's customers have multiple needs. While a clean gel may communicate cleanliness to consumers, solving unmet needs of current poor hand after-feels is even more important. To prepare for next section of sensory work following compositions are being prepared.

5% L' and 95% E" as "BRB 2020A" which targets clarity, super moisturisation, and good hand after-feel.

50% L' and 50% E" as "BRB 2020B" which targets super hand after-feel with moisturisation, softness, silky and natural hand after-feel.

50% L' and 50% I' as "BRB 2020C" which offers super hand after-feel while additional capacity to incorporate additional ingredient to form emulsion.

Table 2:Composition summary of the screening formulations for BRB silicones.

Formulation Code	Blank	PEG-12 Dimethicone	PEG-10 Dimethicone	PEG/PPG-18/18 Dimethicone	Cetyl PEG/PPG-10/18 Dimethicone	TMS	BRB1860	DM55	DM66	Glycerin/ Propylene Glycol
Water	29.40	27.40	27.40	27.40	27.40	27.40	27.40	27.40	27.40	27.40
Carbomer 940	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
TIPA	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Ethanol	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
PEG-12 Dimethicone	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000.00
PEG-10 Dimethicone	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PEG/PPG-18/18 Dimethicone	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
Oatyl PEG/PPG-10/1 Dimethicone	0.00	0.00	0.00	0.00	2.00	2.00	0.00	0.00	0.00	0.00
BRB TMS	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
BRB 1860	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
DM55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00
DM66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00
PG/Glycerin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00

Table 3: Composition summary of the screening formulations for BRB silicones.

Phase	Product	INCI	%
A1	Carbomer 940	Carbomer	0.34
A2	Water	Water	17.4
B1	Triisopropanolamine	Triisopropanolamine	0.26
B2	Water	Water	10.00
C1	BRB Option A,B or C	(See Below)	2.00
C2	Ethanol	Ethanol	70

Procedure: Step 1: Add A1 and A2 and stir well to form homogeneous opaque slurry in one beaker. Step 2: Separately dissolve B1 in B2 in another beaker. Step 3: Gradually add the solution from Step 2 into the slurry in Step 1: Mix well until a thick transparent gel formed. Step 4: Now choose different option A, B and C for different emphases can be added here too. Homogenize the mixture well to form final hand sanitiser.

Three BRB proprietary Blends (option A, B, C) have following compositions:

- 2020A: 5% of BRB 1860 and 95% of BRB 526 (PEG-12 Dimethicone)
- 2020B: 50% of BRB 1860 and 50% BRB 526 (PEG-12 Dimethicone)
- 2020C: 50% of BRB 1860 and 50% BRB 523 (PEG/PPG-18/18 Dimethicone)

Physical properties

Clarity, pH, and viscosity data are summarised in Table 4.

In the study shown in Table 4 there is some learning against the HLB rule intuitively. It is maybe understandable with high HLB from 8 to 13, PEG/PPG-18/18 Dimethicone and PEG-12 Dimethicone can form clear gels, with the latter most easily. However, PEG-10 Dimethicone is a total surprise since its HLB is only 4.5, more on the hydrophobic side. Cetyl PEG/PPG-10/1 Dimethicone only forms cloudy emulsions in this chassis. This is not surprise at all since both low HLB and alkyl moiety prevent enough hydrophilicity.

Without binding by the theory, it is speculated that any sufficient PEG type silicone copolyols without long chain alkyl group, regardless of containing PPG moiety or not, will have a fair chance to yield clear gels in BRB optimised formulation system with some unique combination. All gels had pH around 6, there is no need to drive pH to 7 or higher due to a long buffer zone.

Silicone copolyls can alter the gelling network, sometimes enhanced, other times weaken even destroy the gelling mechanism but never be a bystander as shown in Figure 4. That is the reason the phase diagram work is highly valuable here. Overall higher HLB tends to drop the viscosity more than low HLB. All clear gels here are shear-thinning and have a "short" spreading behaviour. This is a desirable rheological property for consumers. The yield values of them are obvious as they trapped air bubbles during formulation. Such yield value combined with surface activity of silicone copolyols helps to stabilise additional benefit agents, even other insoluble silicones.

Table 4: Physical properties of selected silicone copolyols.

Silicone Copolyols	Cold processable emulsifiers/co-emulsifiers for long stability emulsions	Viscosity (cSt)	Calculated HLB	Water solubility
523	PEG/PPG-18/18 Dimethicone	2,000	8	Yes
526	PEG-12 Dimethicone	300	13	Yes
432	Cetyl PEG/PPG-10/1 Dimethicone	1,250	5	No
6340, 6341	PEG-10 Dimethicone	600	4.5	No

Sensory testing

A six-membered performance panel were used for performance testing. This is a single blind panel. Only the panel director can see the product labels. True ingredient names were masked and only a randomly assigned characters were used for products. The panel director took 2 mL of product by syringe and placed on subjects' hands. The product containers were hidden from all subjects. Subjects then rub each product by hand and report sensory scores to the panel director for records.

After each evaluation subjects washed their hands with soap thoroughly and dry with a clean paper towel. After rest 2 min, subjects resumed the next evaluation. Several repeats were added intentionally to check for score consistency and found to be satisfied.

The sensory scores of all products were summarised in the Table 6 and Figure 6, 7, 8.

Through the sensory panel testing, a good understanding of the winning formulation is gained. Note double transparency from those crystal-clear gels probably carries the most significant weight in overall judgment.

Among five crystal-clear gels, the blank gel is used as baseline which has low scores in perceptions related to moisturisation, softness and skin conditioning. This coincides with the unmet consumer needs. The conventional glycerin/Propylene glycol was used as benchmark control here. It also exhibits with problems: prolonged dry time; tackiness, coated feel and non-silky after-feels. It gives an unnatural feel and does not spread as easily as others too.

This strengthens a reasoning to make the hand sanitiser gels with silicones. Basically, silicones fixed those shortcomings to provide superior sensory after-feels to consumers. BRB1860 gum blend yields a translucent gel, this prevents it being No. 1 in this performance series despite its overall highest scores.

Among four silicone copolyols gels studied, the PEG-12 Dimethicone and PEG-10 Dimethicone are both clear winners in terms of overall performance scores with the PEG/PPG-18/18 Dimethicone gel behind. The Cetyl PEG/PPG-1/10 Dimethicone yields no clear gel, which squarely eliminated it from further consideration. Cost wise PEG-12

Table 5: Summary of physical properties of selected gels in this study.

Performance	Blank	PEG-12 Dimethicone	PEG-10 Dimethicone	PEG/PPG-18/18 Dimethicone	Cetyl PEG/PPG-10/1 Dimethicone	TMS	BRB1860	DM55	DM66	Glycerin/ Propylene Glycol
pH	7.00	7.10	7.00	7.06	7.01	7.06	6.98	7.00	7.00	7.20
Viscosity (Spindle #4, 6RPM, mPa•S)	31400	20000	23500	21500	32300	74300	25000	30600	32000	26800
Viscosity (Spindle #4, 12RPM, mPa•S)	17550	12000	13350	12300	18200	46150	14250	17100	18200	15000
Viscosity (Spindle #4, 30RPM, mPa•S)	8419	5980	6459	6080	8740	Overflow	7000	8300	8800	7260
Viscosity (Spindle #4, 60RPM, mPa•S)	5030	3650	3800	3620	5140	Overflow	4160	4890	5280	4360

Dimethicone is more reasonable.

As in the experiment section, it is proposed to evaluate BRB proprietary products BRB 2020A, 2020B, and 2020C. Those proprietary blends were also checked via sensory and indeed they provide good after-feels with characters while maintaining a high degree of clarity with 2020B leading the scores in Figure 8.

Conclusion

Formulation and benefits of selected silicone ingredients has been systematically explored to be incorporated into hand sanitising gels. Several silicone copolyols can achieve crystal clear thermodynamically stable hand sanitising compositions with the right viscosity and good hand after-feels. Formulation spaces has been greatly expanded to allow formulators' creativity by adding ingredients such as fragrances and vitamin E. Those gels mitigated several sensory shortcomings of either simple or organic polyols (glycerin or propylene glycol) enhanced hand gels. This provides much needed knowledge for formulators in this area to produce better products to combat COVID-19. For formulators who are interested in more information the following literature are available (References 5-9). PC

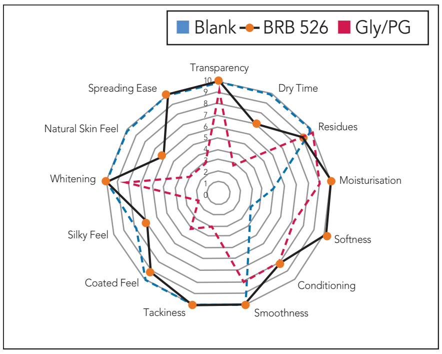

Figure 6: Three-way comparison: Blank, BRB 526, Gly PG

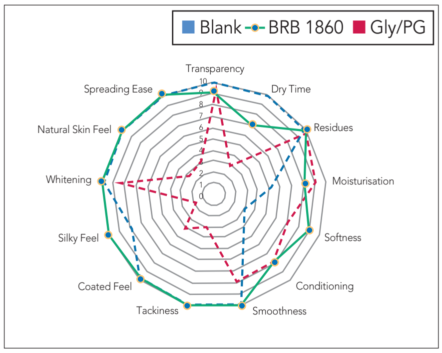

Figure 7: Three-way comparison: Blank, BRB 1860, Gly PG

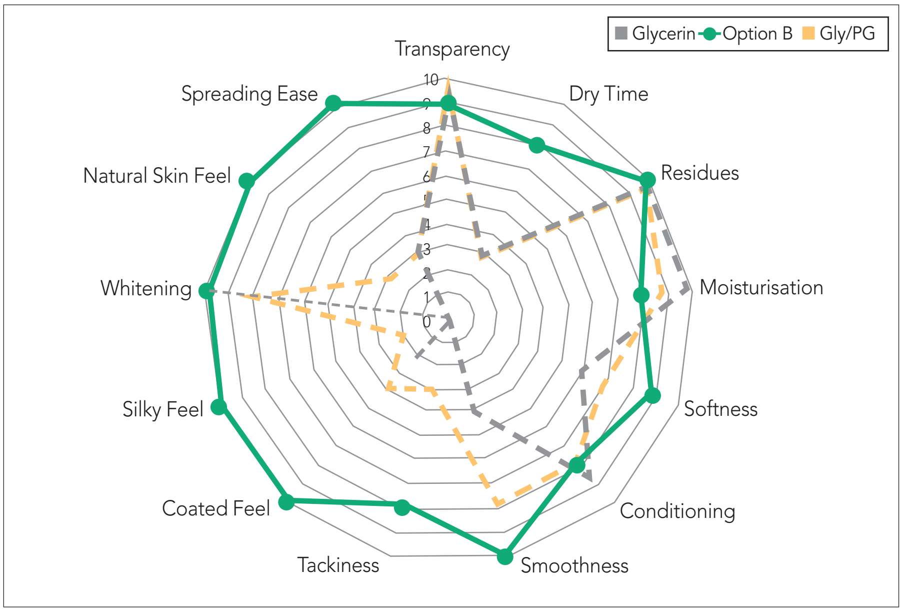

Figure 8: Three-way comparison: Option B, Glycerin, Glycerin PG

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1 Ethanol topical irrigation: www.ncbi.nlm.nih.gov › pmc › articles › PMC2596158
2 TIPA Toxicology Study: https://journals.sagepub.com/doi/pdf/10.3109/10915818709095489
3 WHO-recommended handrub formulations: https://www.ncbi.nlm.nih.gov/books/NBK144054/
4 Ethanol formulation non-irritation but reduced moisturization: https://www.ncbi.nlm.nih.gov/pubmed/17578437
5 U.S. Pat. No. 9,089,129: Non-aerosol foaming alcohol hand sanitizer by Heisig, et al.
6 U.S. Pat. No. 6,723,689: example of high alcohol content sanitizers
7 U.S. Pat. No. 6,423,239: A gel product for use as a skin sanitizer having a higher alcohol content and comprising, humectants, silicones as detackifying agents, moisturizers, and thickeners.
8 https://www.brb-international.com/uploads/markets/brb-personal-care-brochure.pdf
9 https://www.yumpu.com/en/document/view/10005795/formulating-hydroalcoholic-gels-with-carbopol-technical-lubrizol

Table 6: Sensory testing scores of hand sanitisation gels with selected BRB Silicones.

Sensory Descriptives	Blank	PEG-12 Dimethicone	PEG-10 Dimethicone	PEG/PPG-18/18 Dimethicone	Cetyl PEG/PPG-10/1 Dimethicone	TMS	BRB1860	DM55	DM66	Glycerin/PG
Transparency	10	10	10	10	4	0	9	8	8	10
Dry Time	0	3	1	3	3	5	3	2	7	7
Residues	0	1	0	0	1	7	0	0	0	0
Moisturization	5	10	9	4	9	5	8	10	9	9
Softness	3	10	8	6	10	7	9	8	10	7
Conditioning	4	8	9	6	8	6	8	8	9	8
Smoothness	10	10	7	8	8	0	10	7	10	8
Tackiness	0	0	1	2	4	0	0	0	0	7
Coated feel	0	1	3	0	5	10	0	1	2	6
Silky Feel	8	7	7	7	8	5	10	10	8	2
Whitening	0	0	0	0	3	5	0	0	0	1
Natural Skin Feel	10	6	6	8	7	2	10	10	10	3
Spreading Ease	10	10	10	10	5	3	10	10	10	3