

HHS Public Access

Author manuscript *Front Mater.* Author manuscript; available in PMC 2018 January 10.

Published in final edited form as:

Front Mater. 2016 December; 3: . doi:10.3389/fmats.2016.00055.

Screening of Lipid Composition for Scalable Fabrication of Solvent-Free Lipid Microarrays

Lida Ghazanfari and Steven Lenhert*

Department of Biological Sciences, Integrative NanoScience Institute, Florida State University, Tallahassee, FL, USA

Abstract

Liquid microdroplet arrays on surfaces are a promising approach to the miniaturization of laboratory processes such as high-throughput screening. The fluid nature of these droplets poses unique challenges and opportunities in their fabrication and application, particularly for the scalable integration of multiple materials over large areas and immersion into cell culture solution. Here, we use pin spotting and nanointaglio printing to screen a library of lipids and their mixtures for their compatibility with these fabrication processes, as well as stability upon immersion into aqueous solution. More than 200 combinations of natural and synthetic oils composed of fatty acids, triglycerides, and hydrocarbons were tested for their pin-spotting and nanointaglio print quality and their ability to contain the fluorescent compound tetramethylrhodamine B isothiocyanate (TRITC) upon immersion in water. A combination of castor oil and hexanoic acid at the ratio of 1:1 (w/w) was found optimal for producing reproducible patterns that are stable upon immersion into water. This method is capable of large-scale nanomaterials integration.

Keywords

high-throughput screening; droplet microarray; lipid; lipophilic drug; nanointaglio

Specialty section: This article was submitted to Nanobiotechnology, a section of the journal Frontiers in Materials

SUPPLEMENTARY MATERIAL

This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) or licensor are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Correspondence: Steven Lenhert, lenhert@bio.fsu.edu.

Edited by: Jian Zhong, Shanghai Ocean University, China

Reviewed by: Barbara Sanavio, Fondazione IRCCS Istituto Neurologico Carlo Besta, Italy Sílvia Castro Coelho, Faculdade de Engenharia da Universidade do Porto, Portugal

AUTHOR CONTRIBUTIONS

LG carried out the experiments and wrote the manuscript together with SL. SL conceived of the study and directed the experiments.

The Supplementary Material for this article can be found online at http://journal.frontiersin.org/article/10.3389/fmats.2016.00055/ full#supplementary-material.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

INTRODUCTION

A fundamental goal of nanotechnology is to integrate top–down nanofabrication processes with bottom–up chemical assembly to reliably fabricate larger, more complex devices with molecular scale components (Rohrer, 1996). Liquid microdroplet arrays on surfaces are a promising approach toward achieving this goal by allowing multiple solutions to be integrated on a chip (Gosalia and Diamond, 2003; Popova et al., 2016). In principle, each droplet can be viewed as a microscopic test tube, allowing a density of containers limited only by droplet size and the ability to place different reagents into each droplet. For instance, an array with one droplet per square micrometer would allow 100 million containers on 1 cm² surface. The potential in high-throughput screening (HTS), with the state of the art being 10–30 wells/cm, is comparable to the difference in capabilities between early vacuum tube-based computer mainframes and today's solid-state computers.

Modern HTS requires robotics, liquid-handling devices, sensitive detectors, and software for data processing and control in order to perform millions of pharmacological tests on samples in parallel. Current robotic systems are burdened by several issues, such as high costs, poor reliability of data, standardization of data types, rapid and accurate dispensing of very small liquid volumes, and uncontrolled evaporation of dispensed liquids from Comley (2006). One promising approach to miniaturization of HTS is microfluidics. Microfluidic systems enable serial processing and analysis and, furthermore, can accomplish massive parallelization through efficient miniaturization and multiplexing (Hong et al., 2009). In particular, droplet microfluidics use small droplets, typically water suspended in oil, to confine reagents and/or cells (Anna et al., 2003; Kim et al., 2015). A challenge in this field is that the droplets move and mix in solution, and a chemical tracker is therefore typically included in the drop for identification. Droplet microarrays provide a different solution to this technical challenge by attaching the droplet to a surface, so that its composition is known by its position in the array, at the cost of limiting the array to two dimensions (Gosalia and Diamond, 2003; Mugherli et al., 2009; Arrabito et al., 2013; Sun et al., 2015; Popova et al., 2016).

Microarrays of covalently attached monolayers are well established and allow the simultaneous analysis of thousands of chemical entities within a single experimental step (Cahill, 2001; Heller, 2002; Pirrung, 2002; Howbrook et al., 2003; Hook et al., 2006; Ma and Horiuchi, 2006). Biomolecules commonly immobilized on microarrays include proteins (Cahill, 2001), oligonucleotides (Heller, 2002; Pirrung, 2002; Howbrook et al., 2003), polymerase chain reaction products (Heller, 2002; Pirrung, 2002), peptides (Cahill, 2001; Howbrook et al., 2003), lipids (Howbrook et al., 2003; Hook et al., 2006), and carbohydrates (Ma and Horiuchi, 2006). Covalent small molecule microarrays are useful for screening for interactions with the surfaces of adherent cells. However, targets inside of the cell are inaccessible to this approach. Alternatives include embedding the small molecules into a matrix such as a hydrogel and allowing them to diffuse out (Bailey et al., 2004), a sandwich assay composed of microwells that are addressable by individual posts (Wu et al., 2011), or by generating arrays of microscopic water droplets for cell culture (Popova et al., 2016). These methods are promising for water-soluble compounds. However, an estimated 40% of approved drugs in the market and nearly 90% of molecules in the developmental pipeline are poorly water soluble (Kalepu and Nekkanti, 2015). This poses a challenge for delivery to

cells through aqueous solution. We use lipid multilayer (or droplet) microarrays to temporarily immobilize lipophilic compounds onto a surface, allowing cellular uptake and quantitative dose–response curves (Kusi-Appiah et al., 2012; Kusi-Appiah et al., 2015). A crucial property of lipid multilayer microarrays for drug screening applications is that the layer must be thicker than a single monolayer or bilayer in order to contain enough drug to reach biologically relevant dosages upon cellular uptake.

Lipid multilayer microarrays have been be fabricated by dip pen nanolithography (Lenhert et al., 2007), polymer pen lithography (Hirtz et al., 2015), nanointaglio printing (Lowry et al., 2014), and evaporative edge lithography (Vafai et al., 2015). Here, we use nanointaglio printing, which is a printing mode where ink is transferred from the recesses of a stamp, allowing for control of lipid multilayer film thicknesses by the stamp dimensions as well as the amount of ink on the stamp (Nafday et al., 2012). We have previously demonstrated that three different lipids can be integrated over larger areas by pin spotting of lipid solutions onto a palette, which is subsequently used to ink the intaglio stamp (Lowry et al., 2014). In order to scale this process up for integration of thousands of different lipid encapsulated drug candidates for HTS, several obstacles must be overcome. First of all, we have previously used liposomal solutions in water for the microarray process, yet solvent evaporation becomes an issue as more compounds are added. Second, immersion of the lipid microarrays into water poses a challenge, as the lipids can sometimes be swept away upon addition of aqueous solution. In order to solve these problems, we here screen different fluid lipid carriers as a suitable matrix for solvent-free microarraying followed by intaglio printing and immersion into water. Our main objective here is to identify a fluid lipid composition capable of containing lipophilic small molecules and compatible with pin spotting and microarraying so that this process can be scaled up for HTS applications (Figure 1).

MATERIALS AND METHODS

Components

As shown in Figure 2, the components of the lipid formulations screened here include fatty acids [octanoic (caprilic) acid, hexanoic (caproic) acid, oleic acid, linoleic acid], triglycerols (olive oil, soybean oil, sesame oil, peanut oil, linseed oil, corn oil, cottonseed oil, castor oil, lavender oil, mineral oil, sunflower oil, safflower oil, canola oil, fish oil)/hydrocarbon (hexadecane), glycerol, and tetramethylrhodamine B isothiocyanate (TRITC), as the fluorescent hydrophobic model drug, which are purchased from Sigma-Aldrich. The combinations of 1:1 (w/w) liquid lipids and the pure lipids are tested (Table 1). The oil phase must be of high purity and free of undesirable components such as peroxides, pigments, decomposition products, and unsaponifiable matter such as sterols and polymers. Oxidation of oil and drug during preparation and storage must be minimized by manufacturing under a nitrogen atmosphere, as reported by Floyd (1999).

PDMS Stamps

PDMS micro-well stamps are prepared from a thermoplastic master (EV Group, Inc., Tempe, AZ, USA) cured from a patterned silicon wafer with 5 μ m diameter wells, 2.5 μ m deep and 10 μ m in pitch, covering 19% of the stamp surface. The silicon wafers are initially

cleaned with piranha solution or plasma treated and later passivated with a 0.2% (by volume) octadecyltrichlorosilane solution in toluene. The PDMS stamp of desired dimensions is prepared from a Sylgard 184 (Dow Corning, Midland, MI, USA) elastomer gel at a ratio of 1:10 curing agent to base prepolymer poured over the thermoplastic master and cured in an oven at 65°C overnight.

Ink Preparation

For integration of multiple inks, TRITC, as a model drug, is added to the liquid lipids at a proportion of 1% by mass for arraying, screening, and microscopy. The results are microarrayed in an array pattern onto a PDMS ink palette.

Microarraying Lipid Components

The different lipid solutions are microarrayed from standard 384-well microtiter plates (Axygen, Inc., PMI110-07 V1, Union City, CA, USA) using a Microarrayer (Arrayit Corporation, ARYC) onto the PDMS palettes (Figure 3 and Figure S1 in Supplementary Material), using a 200 μ m 4 × 4 stainless steel microspot pin tool. Microarray pins are washed to ensure no cross-contamination between inks. It is found that 2 min washes in acetone and then water, followed by 30 sec of drying sufficed.

Intaglio Printing

For lipid/dye combination stamping on the cover glass palette surfaces, the PDMS stamp is inked and placed in contact with the substrate. A structured PDMS stamp is inked by pressing the patterned surface onto the ink palette (Lowry et al., 2014). The stamping procedure combines the topographical control of nanoimprint lithography and throughput of microcontact printing with the scalability of pin spotting. The stamps are left in direct contact with the surface and uniform, firm pressure (about 45 N as measured on a bathroom scale) is applied for ~10 sec before careful removal and printing the next pattern. Excess material is removed by sacrificially printing four to six times before pattern would print uniformly. Image analysis for area and intensity of the droplets is done by NIH ImageJ software (http://rsb.info.nih.gov/ij/) (Figure 4A; Figure S2 in Supplementary Material).

Quantitative analysis of pin spotting screening of liquid lipid-based components, together with the Z value of the components, is shown in Figure 4. Furthermore, a scatter plot of the two parameters tested (intensity and droplet area) is provided (Figure 5).

For Figure 6 and Figure S3 in Supplementary Material, nanointaglio patterns are printed on glass coverslip substrates. Furthermore, quantitative analysis of the printing compatibility screening of liquid lipid-based components and their Z values are shown in Figure 7. The description of the correlation of intensity and print area is provided in Figure 8.

Lipid Nanopattern Storage and Immersion

After nanointaglio fabrication, lipid patterns are stored in a nitrogen glovebox (Mbraun, Inc., Model Labstar (1200/780), Stratham, NH, USA) to prevent them from possible oxidation. The nitrogen environment stabilizes the lipid nanostructures by dehydration prior to immersion in water (Lenhert et al., 2010). Then Millipore water is applied for 1 h, using a

syringe directly over a section of the lipid pattern on a microscope stage while the pattern is being imaged on fluorescence microscope (Figure 9). Moreover, we repeat the same experiment for the selected components over a large pattern. This time after being imaged for 1 h, the patterns are kept at ambient temperature $(25^{\circ}C \pm 2\%)$ for 72 h and are imaged again by fluorescence microscopy.

Preparation of Immersion Chamber

A 0.5 cm diameter cork bore is used to create cutouts in PDMS pieces 1 cm wide by 3 cm long by 0.5 cm thick. This chamber is placed on a glass slide with the lipid patterns to create an enclosed space to contain solution for experiments.

Characterization and Imaging Techniques

A Ti-E epifluorescence inverted microscope (Nikon Instruments, Melville, NY, USA) fitted with a Retiga SRV (QImaging, Canada) CCD camera (1.4 MP, Peltier cooled to -45° C) is used for fluorescence and bright-field imaging of the lipid patterns on glass surfaces. All experiments are performed at ambient temperature.

Statistical Analysis

All experiments are performed at least in triplicate. The screening data are repeated three times on three different days. Means and SEs of the means are calculated using Excel. MATLAB software is used to perform the Z score calculations. The raw intensity and droplet area data for each experiment are used for the calculation of Z scores. Z scores are calculated by subtracting the overall average of either intensity or droplet area (within a single experiment) from the raw intensity or droplet area data for each component and dividing that result by the SD of all the measured intensities or droplet areas, according to the formula:

Z score=(intensity_c - mean intensity_{C1 - Cn})/SD_{C1...Cn}

where C is any component on the microarray and $C1 \dots Cn$ represent the aggregate measure of all of the components.

RESULTS AND DISCUSSION

Lipids (long-chain triglycerols—LCTs and medium-chain triglycerols—MCTs) approved by the regulatory agencies, alone or in combination, are generally first choice for developing drug carrier formulations (Marten et al., 2006; Hippalgaonkar et al., 2010). LCTs such as soybean oil, safflower oil, sesame oil, and castor oil are approved for clinical use. Some oils (e.g., safflower, olive, sunflower, and castor) that contain more than 70% of oleic, linoleic, or ricinoleic acids make the larger spots. Our microarray includes both LCTs and MCTs and their combinations. Some oils such as linseed, safflower, and olive oils have higher fluorescence intensity, which is attributed to their autofluorescence properties (Sikorska et al., 2012). It is worth mentioning that the maximum fluorescence intensity of each spot is used in analyzing the data. Also, area values that are smaller than 3000 μ m² have not been considered.

In the fluorescence micrograph of the palette presented in Figure 3 (Figure S1 in Supplementary Material), it is evident that not all the lipid mixtures are compatible with the pin-spotting step. Some of the components have not been pin spotted properly, as they show no fluorescence intensity. In addition, some of the samples have covered very limited area, which is almost negligible. In Figure 4B, Z scores provide a relative, semiquantitative estimate of either intensity or droplet area levels and, as such, form the basis of comparison of either intensity or droplet area data among many experiments within the same array type. Thus, Z scores provide a useful and intuitive method for visualizing and interpreting very large amounts of data in their natural physicochemical context. This is in contrast to normalization strategies that express either intensity or droplet area data as ratios of one sample to another (either experimental or to a common reference sample). Positive and negative values in these analyses simply indicate their relationship to the normalizing sample rather than reflecting actual area or intensity levels. The very brightest dots are saturated, indicating that a sufficiently large amount of dye per dot as fluorescence intensity is related to droplet height (Nafday and Lenhert, 2011). Droplet area is likely related to both droplet volume and the contact angle of the oil on the glass surface. The viscosity of the oil and contact time of the tip may also play a role in the lipid transfer from the pin to the surface.

Castor oil, which contains monounsaturated fatty acyls, shows the most stable formulation after immersion, especially when combined with other components. Vegetable oils contain various triglycerides in different proportions; castor oil, in particular, deviates from the other oils by the high content of a monounsaturated fatty acid [ricioleic acid, 18:19 (12OH)] with a hydroxy group. For example, the free fatty acids contained in castor oil can act as a coemulsifier resulting in lower interfacial tension and more stable formulation in comparison with the other oil phases (Mohan et al., 2012). Compared to other vegetable oils, castor oil exhibits enhanced solubilizing effects that can be ascribed to increased hydrogen bonding activities of the hydroxyl groups in ricinoleic acids.

Furthermore, it has been shown that by combining castor oil and a liquid fatty acid, at the ratio of 1:1 (w/w), the stability of the material under water is increased. Jumaa and Muller (1998, 1999) reported the effect of mixing castor oil with medium chain triglycerides on the viscosity of castor oil. The oil combination, at the ratio of 1:1 (w/w), led to a decrease in the viscosity of castor oil and simultaneously to a decrease in the interfacial tension of the oil phase (Mohan et al., 2012). This was related to the free fatty acids contained in castor oil, which can act as a coemulsifier resulting in lower interfacial tension and, simultaneously, in a more stable formulation in comparison with the other oil phases.

In our microarray, castor oil/hexanoic acid (MCT), castor oil/octanoic acid (MCT), and castor oil/olive oil (LCT) combinations make small patterns after pin spotting with almost uniform light intensity distribution throughout the sample, and they make good printed patterns that are reproducible. As shown in Figure 9, for castor oil/hexanoic acid combination, an irregular pattern of droplets is formed.

The dots are stable after immersion under water for 1 h in terms of the size, which demonstrates that the dots are not spreading; however, their intensity decreased during the time. As shown in Figure 10A, castor oil/octanoic acid combination shows almost complete

fluorescence recovery 72 h after immersion under water. Intensities shown in Figure 10 represent the average of 30 different areas measured on three different replicate samples (10 images each). The castor/olive oil combination shows a lower fluorescence recovery compared to the castor oil/octanoic acid combination. However, the castor oil/hexanoic acid combination shows a continuous decrease in fluorescence during that time. The latter finding may suggest a mixture more prone to TRITC (and maybe drug) release over time in aqueous solutions.

Both castor oil and MCTs (hexanoic acid) are among the excipients that are being used for the manufacturing of ocular compatible lipid emulsion (Mohan et al., 2012). However, prior to the formulation of the lipid emulsions, data are needed concerning drug solubility in the oil vehicle. In addition, information is needed on compatibility of the oil vehicle with other formulation additives and with the established ocular tissue, before the dosage forms can be prepared. Our results indicate that microdroplet arrays of castor oil combinations on surfaces are suitable for screening of drugs in a scalable manner.

CONCLUSION

A screen was carried out to identify oils compatible with pin spotting and nanointaglio, followed by immersion of the microarray into water. We tested 210 lipid formulations, and a 1:1 mixture of castor oil and hexanoic acid was found to be optimal in terms of droplet size, reproducibility of printed patterns, florescence intensity, and stability under immersion. Compared to phospholipid carriers (Kusi-Appiah et al., 2015), this formulation can be arrayed without the need for an additional solvent. The lipid itself can be considered the solvent for the fabrication of drug screening microarrays. These "solvent-free" lipid multilayer microarrays have potential for HTS of lipophilic compounds.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

LG would like to thank Aubrey Kusi-Appiah at the Florida State University for helpful discussions. The authors thank Jen Kennedy for proofreading.

FUNDING

This work was supported by NIH R01 GM107172.

References

- Anna SL, Bontoux N, Stone HA. Formation of dispersions using "flow focusing" in microchannels. Appl Phys Lett. 2003; 82:364–366. DOI: 10.1063/1.1537519
- Arrabito G, Galati C, Castellano S, Pignataro B. Luminometric sub-nanoliter droplet-to-droplet array (LUMDA) and its application to drug screening by phase I metabolism enzymes. Lab Chip. 2013; 13:68–72. DOI: 10.1039/c2lc40948h [PubMed: 23132304]
- Bailey SN, Sabatini DM, Stockwell BR. Microarrays of small molecules embedded in biodegradable polymers for use in mammalian cell-based screens. Proc Natl Acad Sci USA. 2004; 101:16144– 16149. DOI: 10.1073/pnas.0404425101 [PubMed: 15534212]

- Cahill DJ. Protein and antibody arrays and their medical applications. J Immunol Methods. 2001; 250:81–91. DOI: 10.1016/S0022-1759(01)00325-8 [PubMed: 11251223]
- Comley, J. Tools and technologies that facilitate automated screening. In: Hueser, J., editor. High-Throughput Screening in Drug Discovery. Weinheim: Wiley-VCH; 2006. p. 37-73.
- Floyd AG. Top ten considerations in the development of parenteral emulsions. Pharm Sci Technol Today. 1999; 2:134–143. DOI: 10.1016/S1461-5347(99)00141-8
- Gosalia DN, Diamond SL. Printing chemical libraries on microarrays for fluid phase nanoliter reactions. Proc Natl Acad Sci USA. 2003; 100:8721–8726. DOI: 10.1073/pnas.1530261100 [PubMed: 12851459]
- Heller MJ. DNA microarray technology: devices, systems, and applications. Annu Rev Biomed Eng. 2002; 4:129–153. DOI: 10.1146/annurev.bioeng.4.020702.153438 [PubMed: 12117754]
- Hippalgaonkar K, Majumdar S, Kansara V. Injectable lipid emulsions advancements, opportunities and challenges. AAPS PharmSciTech. 2010; 11:1526–1540. DOI: 10.1208/s12249-010-9526-5 [PubMed: 20976577]
- Hirtz, M., Sekula-Neuner, S., Urtizberea, A., Fuchs, H. Functional lipid assemblies by dip-pen nanolithography and polymer pen lithography. In: Chen, X., Fuchs, H., editors. Soft Matter Nanotechnology: From Structure to Function. Weinheim: Wiley-VCH; 2015. p. 161-185.
- Hong J, Edel JB, deMello AJ. Micro- and nanofluidic systems for high-throughput biological screening. Drug Discov Today. 2009; 14:134–146. DOI: 10.1016/j.drudis.2008.10.001 [PubMed: 18983933]
- Hook AL, Thissen H, Voelcker NH. Surface manipulation of biomolecules for cell microarray applications. Trends Biotechnol. 2006; 24:471–477. DOI: 10.1016/j.tibtech.2006.08.001 [PubMed: 16919345]
- Howbrook DN, van der Valk AM, O'Shaughnessy MC, Sarker DK, Baker SC, Lloyd AW. Developments in microarray technologies. Drug Discov Today. 2003; 8:642–651. DOI: 10.1016/ S1359-6446(03)02773-9 [PubMed: 12867150]
- Jumaa M, Muller BW. The effect of oil components and homogenization condition on the physicochemical properties and stability of parenteral fat emulsions. Int J Pharm. 1998; 163:81– 89. DOI: 10.1016/S0378-5173(97)00369-4
- Jumaa M, Muller BW. Physicochemical properties of chitosan-lipid emulsions and their stability during the autoclaving process. Int J Pharm. 1999; 183:175–184. DOI: 10.1016/ S0378-5173(99)00086-1 [PubMed: 10361168]
- Kalepu S, Nekkanti V. Insoluble drug delivery strategies: review of recent advances and business prospects. Acta Pharm Sin B. 2015; 5:442–453. DOI: 10.1016/j.apsb.2015.07.003 [PubMed: 26579474]
- Kim M, Pan M, Gai Y, Pang S, Han C, Yang C, et al. Optofluidic ultrahigh-throughput detection of fluorescent drops. Lab Chip. 2015; 15:1417–1423. DOI: 10.1039/c4lc01465k [PubMed: 25588522]
- Kusi-Appiah AE, Lowry TW, Darrow EM, Wilson KA, Chadwick BP, Davidson MW, et al. Quantitative dose-response curves from subcellular lipid multilayer microarrays. Lab Chip. 2015; 15:3397–3404. DOI: 10.1039/c5lc00478k [PubMed: 26167949]
- Kusi-Appiah AE, Vafai N, Cranfill PJ, Davidson MW, Lenhert S. Lipid multilayer microarrays for in vitro liposomal drug delivery and screening. Biomaterials. 2012; 33:4187–4194. DOI: 10.1016/ j.biomaterials.2012.02.023 [PubMed: 22391265]
- Lenhert S, Brinkmann F, Laue T, Walheim S, Vannahme C, Klinkhammer S, et al. Lipid multilayer gratings. Nat Nanotechnol. 2010; 5:275–279. DOI: 10.1038/nnano.2010.17 [PubMed: 20190751]
- Lenhert S, Sun P, Wang Y, Fuchs H, Mirkin CA. Massively parallel dip-pen nanolithography of heterogeneous supported phospholipid multilayer patterns. Small. 2007; 3:71–75. DOI: 10.1002/ smll.200600431 [PubMed: 17294472]
- Lowry TW, Kusi-Appiah A, Guan J, Van Winkle DH, Davidson MW, Lenhert S. Materials Integration by nanointaglio. Adv Mater Interfaces. 2014; 1:1300121–1300125. DOI: 10.1002/admi. 201300127
- Ma H, Horiuchi KY. Chemical microarray: a new tool for drug screening and discovery. Drug Discov Today. 2006; 11:661–668. DOI: 10.1016/j.drudis.2006.05.002 [PubMed: 16793536]

- Marten B, Pfeuffer M, Schrezenmeir J. Medium-chain triglycerides. Int Dairy J. 2006; 16:1374–1382. DOI: 10.1016/j.idairyj.2006.06.015
- Mohan K, Pravin S, Atul B. Ophthalmic microemulsion: a comprehensive review. Int J Pharma Bio Sci. 2012; 3:1–13.
- Mugherli L, Burchak ON, Balakireva LA, Thomas A, Chatelain F, Balakirev MY. In situ assembly and screening of enzyme inhibitors with surface-tension microarrays. Angew Chem Int Ed. 2009; 121:7775–7780. DOI: 10.1002/ange.200901139
- Nafday OA, Lenhert S. High-throughput optical quality control of lipid multilayers fabricated by dippen nanolithography. Nanotechnology. 2011; 22:225301.doi: 10.1088/0957-4484/22/22/225301 [PubMed: 21464525]
- Nafday OA, Lowry TW, Lenhert S. Multifunctional lipid multilayer stamping. Small. 2012; 8:1021–1028. DOI: 10.1002/smll.201102096 [PubMed: 22307810]
- Pirrung MC. How to make a DNA chip. Angew Chem Int Ed. 2002; 41:1276–1289. <1276::AID-ANIE1276> 3.0.CO;2-2. DOI: 10.1002/1521-3773(20020415)41:8
- Popova AA, Demir K, Hartanto TG, Schmitta E, Levkin PA. Droplet-microarray on superhydrophobicsuperhydrophilic patterns for high-throughput live cell screenings. RSC Adv. 2016; 6:38263– 38276. DOI: 10.1039/C6RA06011K
- Rohrer H. The nanoworld: chances and challenges. Microelectron Eng. 1996; 32:5–14. DOI: 10.1016/0167-9317(95)00173-5
- Sikorska, E., Khmelinskii, I., Sikorski, M. Boskou, D., editor. Analysis of olive oils by fluorescence spectroscopy: methods and applications. Olive Oil Constituents, Quality, Health Properties and Bioconversions. 2012. (InTech)Available at: http://www.intechopen.com/books/olive-oil-constituents-quality-health-properties-and-bioconversions/analysis-of-olive-oils-by-fluorescence-spectroscopy-methods-and-applications
- Sun Y, Chen X, Zhou X, Zhu J, Yu Y. Droplet-in-oil array for picoliter-scale analysis based on sequential inkjet printing. Lab Chip. 2015; 15:2429–2436. DOI: 10.1039/c5lc00356c [PubMed: 25904463]
- Vafai N, Lowry TW, Wilson KA, Davidson MW, Lenhert S. Evaporative edge lithography of a liposomal drug microarray for cell migration assays. Nanofabrication. 2015; 2:32–42. DOI: 10.1515/nanofab-2015-0004
- Wu J, Wheeldon I, Guo Y, Lu T, Du Y, Wang B, et al. A sandwiched microarray platform for benchtop cell-based high throughput screening. Biomaterials. 2011; 32:841–848. DOI: 10.1016/ j.biomaterials.2010.09.026 [PubMed: 20965560]

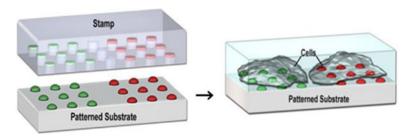


FIGURE 1.

Schematic showing the nanointaglio fabrication process (left) and its application in cellbased high-throughput screening.

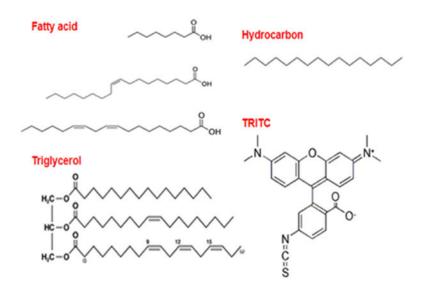


FIGURE 2.

Sample chemical structures of the different classes of compounds screened here (fatty acids, triglycerols, hydrocarbon, and tetramethylrhodamine B isothiocyanate as the fluorescent hydrophobic model drug).

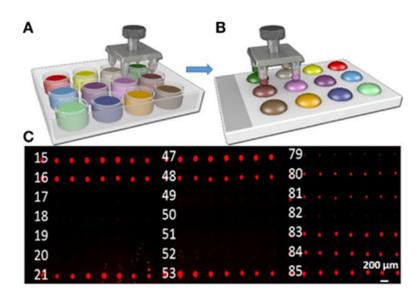


FIGURE 3. Pin spotting screening of liquid lipid-based components

(A,B) Schematic illustrating the process of inking of lipid spots; (C) fluorescence micrographs of palette. Scale bar is 200 μ m.

Ghazanfari and Lenhert

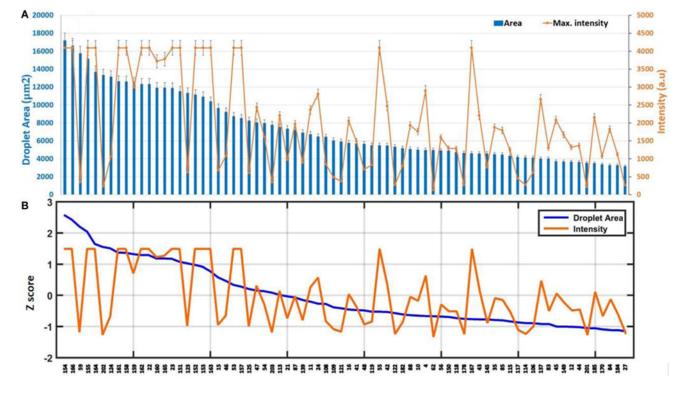


FIGURE 4.

(A) Quantitative analysis of pin spotting screening of liquid lipid-based components in terms of droplet area and intensity. Error bars represent the SEM of at least nine different spots.(B) *Z* value of the components.

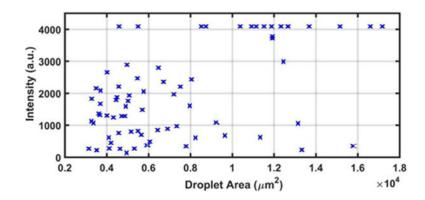


FIGURE 5. Plot of intensity versus droplet area of pin spotting screening of liquid lipid-based components

The brightest dots are saturated in fluorescence intensity, indicating sufficient dye content for our purposes.

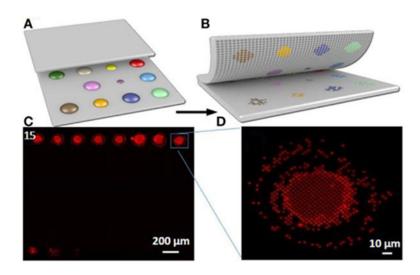


FIGURE 6. Nanointaglio print compatibility screening of liquid lipid-based components in terms of area and intensity

(A,B) Schematic illustrating the process of nanointaglio printing of lipid spots; (C) fluorescence micrograph of a lipid microarray printed using the nanointaglio method; (D) magnified section of (C) indicated by blue square in (C).

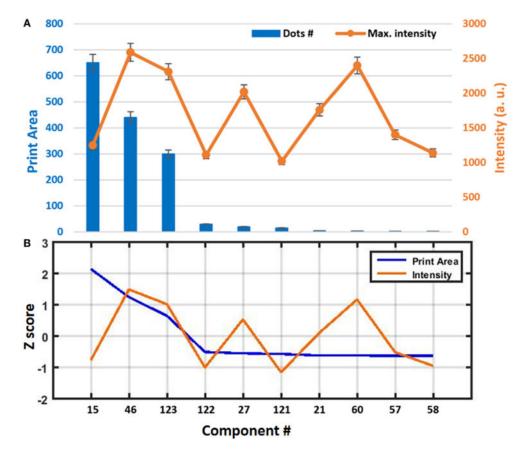


FIGURE 7.

(A) Quantitative analysis of the print compatibility screening of liquid lipid-based components in terms of print area and intensity. Error bars represent the SEM of at least nine different spots. (B) Z value of the components.

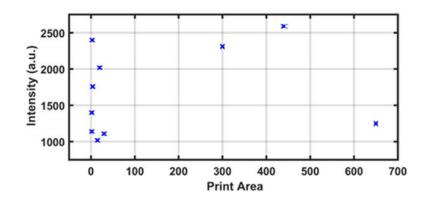


FIGURE 8.

Plot of intensity versus print area of printing compatibility screening of liquid lipid-based components.

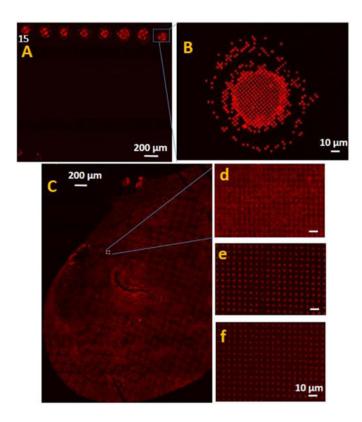


FIGURE 9. The effect of immersion under water on liquid lipid stability of the samples stored under nitrogen atmosphere

(A) Fluorescence micrographs of castor oil/hexanoic acid combination in lipid microarray format 1 h after immersion under water and (B) magnified section of (A). (C) Fluorescence micrograph of a large spot of castor oil/hexanoic acid combination printed using the nanointaglio method, (D) magnified section of (C) indicated by blue square in (C); (E) fluorescence micrographs of the same spot after 1 h and (F) after 72 h immersion under water.

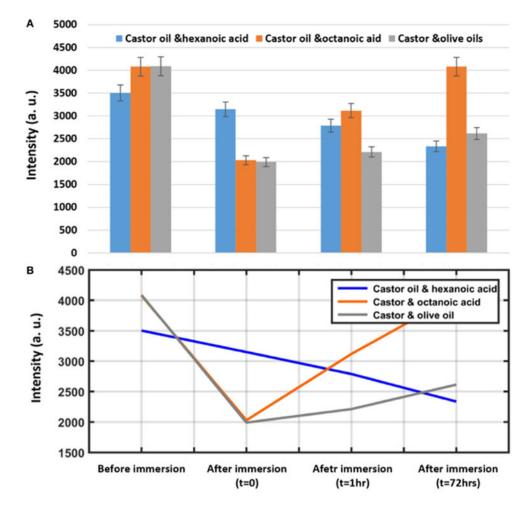


FIGURE 10.

(A) Quantification of fluorescence intensity change of a spot printed using the nanointaglio method before immersion, immediately after immersion (t = 0), and 1 and 72 h after immersion under water. Error bars represent the SEM of three different replicates. (B) Descriptive analysis of intensity versus time.

TABLE 1

List of components [the combinations have the ratio of 1:1 (w/w)].

1 4.3 Octanoic and diverse and controls and object and controls and					-
centonic 4 Octanoic and comol 86 Peamt and inseed 128 Olive and glycerol 170 Safflower and glycerol 4 Hexanoic and linked 40 Octanoic and caro 87 Peamat and safflower 130 Soybean and olive 172 Sufflower and glycerol 173 Sufflower and glycerol 173 Sufflower and glycerol 173 Sufflower and glycerol 173 Sufflower and glycerol 174 Sufflower and glycerol 175 Sufflower and glycerol 175 Sufflower and glycerol 175 Sufflower and glycerol 176 Sufflower and glycerol 175 Sufflower and glycerol 176 Sufflower and glycerol 176 Sufflower and glycerol 176 Sufflower and glycerol 178 Sufflower and glycerol 1	1 Hexanoic acid only	43 Octanoic and	85 Peanut and	127 Olive and	169 Safflower and
3 Hexanoic and looket 4 45 Octanoic and sesame 47 75 Penanti and sufforer 89 129 Soybean and olive 130 171 Sunflower and olive 47 6 Hexanoic and olive 47 Octanoic and fish mineral 60 Hexanoic and olive 47 171 Sunflower and 48 6 Hexanoic and opeant 47 Dectanoic and mineral 90 Peanti and castor 47 132 Soybean and 433 Soybean and 433 Soybean and 433 Soybean and 433 Soybean and 434 Soybean and 435 Soybean and 436 Soybean and 435 Soybean and 435 Soybean and 435 Soybean and 436 Torma and castor 436 Torma and castor 436 Torma and castor 437 Soybean and 436 Torma and castor 436 Torma and castor 437 Torma and castor 436 Torma and castor 437 Torma and castor 436 Torma and castor 437 Torma and castor 438 Torma and castor 438 Torma and soybean 434 Torma and soybean 435 Torma and soybean 436 Torma and soybean 437 Torma and soybean 436 Torma and soybean 437 Torma a	2 Hexanoic and	sunflower	cottonseed	hexadecane	hexadecane
4 Hexanoi: and linolet: 46 Octanoic and carlos sunflower 130 Soybean and offer 171 Sunflower and	octanoic	44 Octanoic and canola	86 Peanut and linseed	128 Olive and glycerol	170 Safflower and
5 Hexanoic and olive 131 Snybean and symbol 122 Snybean and symbol Canalog	3 Hexanoic and oleic	45 Octanoic and sesame	87 Peanut and safflower	129 Soybean oil only	glycerol
system48Octanoic and 099Peanut and canola 123Peanut ' 214Peanut ' 215Peanut ' 215Peanut ' 215Peanut and 213Peanut ' 215Peanut and 213Peanut ' 215Peanut and 213Peanut and 213			88 Peanut and	130 Soybean and olive	171 Sunflower oil only
of Hexanoic and opeanut mineral 90 Peanut and sesame 132 Soybean and 173 Sunflower and 8 Hexanoic and eanut Inseed 133 Soybean and 174 Sunflower and 9 Hexanoic and 51 Octanoic and 92 Peanut and lineed 134 Soybean and 175 Sunflower and 11 Hexanoic and 51 Octanoic and 92 Peanut and lineed 135 Soybean and 175 Sunflower and 11 Hexanoic and 52 Crom and lineed 94 Peanut and livered 136 Soybean and 175 Sunflower and 13 Hexanoic and eastor 55 Corn and sunflower 99 Linoleic and cont 138 Soybean and 178 Sunflower and 14 Hexanoic and 55 Corn and sesame 101 Linoleic and 138 Soybean and 178 Soybean and 180 Canola and sesame 15 Hexanoic and 65 Corn and sesame 104 Linoleic and 138 Soybean and 182 Canola and 179 Sunflo				~	
7 Hexanoic and cornot 49 Octanoic and sumfore 50 Octanoic and sumfore 51 Octanoic and sumfore 52 Soybean and sumfore 13 Soybean and sumfore 13 Soybean and sumfore 175 Sumforer and sumforer 176 Sumforer and sumforer 178 Sumforer and sumforer 183 Corn and sumforer 183 Corn and sumforer 183 Corn and sumforer 184 Corn and sumforer <td></td> <td></td> <td></td> <td></td> <td></td>					
8 Hexanoic and coron Javender 92 Peanut and fish and sender 134 Stybean and cator 10 Hexanoic and slipcerol 94 Peanut and lavender 134 Stybean and cator 175 Sunflower and slipcerol 11 Hexanoic and slipcerol 95 Peanut and lavender 135 Stybean and cator 176 Sunflower and slipcerol 12 Hexanoic and canola 55 Corn and sufflower 97 Linoleic and olive seame 178 Stybean and cator 179 Stybean and cator 182 Cator and styb				5	
9 10 Decamoic and py evenol 93 Peanut and lavender py evenol 14 Soybean and py evenol castor 10 Hexanoic and py evenol 51 Octamoic and py evenol 95 Peanut and layende py evenol 135 Soybean and py evenol 175 Sunflower and hexadecane 11 Hexanoic and sufflower 52 Corn on distantioner 90 Peanut and layende py evenol 136 Soybean and py evenol 178 Sunflower and hexadecane 12 Hexanoic and castor 50 Corn and sunflower 90 Linoleic and only py evenol 138 Soybean and py evenol 178 Sunflower and hexadecane 13 Hexanoic and sunflower 60 Corn and sunflower 101 Linoleic and hower 114 Soybean and sunflower 181 Canola and and mineral 16 Hexanoic and hexadecane 63 Corn and sunflower 103 Linoleic and sunflower 183 Canola and and sessure py evenol 182 Canola and fish hexadecane 184 Canola and fish hexadecane 184 Canola and fish hexadecane 184 Canola and fish hexadecane 184 Canola and fish hexadecane 185 Canola and hexadeca	1			5	
cottonseedhexadecane94Peanut and lavender175Sunflower and10Hexanoic and52Corn oil only96Peanut and lycerol135Soybean and176Sunflower and fahsufflower53Corn and insole97Linoleic and oils136Soybean and175Sunflower and11Hexanoic and53Corn and sufflower97Linoleic and oils137Soybean and137Soybean and138Soybean and136130Canola ia and136Soybean and136Soybean and136130Canola ia and136Soybean and136130Canola ia and136Soybean and136Soybean136Soybean136Soybean136Soybea					
10 Persanoic and linseed 51 Octanoic and 52 Corn oil only 53 95 Penut and 96 135 Soybean and 536 becadecane linseed 11 Hexanoic and sufflower 53 Corn and conseed 55 Corn and sufflower 55 Corn and sufflower 56 Corn and sufflower 55 Corn and sufflower 56 Corn and sufflower 57 Corn and sufflower 59 Linoleic and oine 59 Linoleic and oine 59 Linoleic and oine 55 Linoleic and corn 55 Linoleic and corn 56 Linoleic and corn 56 Linoleic and corn 56 Linoleic and corn 57 Linoleic and corn 58 Linoleic and corn 59 Linoleic and corn 59 Linoleic and corn 55 Linoleic and corn 55 Linoleic and corn 55 Linoleic and corn 55 Linoleic and corn 56 Linoleic and corn 57 Linoleic and corn 56 Linoleic and corn 57					
linseed saflowergycerol tanolesbexadecane beanut and yearinseed tanoles'176Sunflower and fish mineral11Hexanoic and sunflower53Corn and sunflower97Linoleic acid only softwer137Soybean and canola isseed138Soybean and canola isseed138Soybean and fish lavender138Soybean and fish lavender138Soybean and fish lavender138Soybean and fish lavender138Soybean and fish lavender138Soybean and fish lavender138Conal al acestor130Canola and sesame15Hexanoic and fish of Corn and fish lavender102Linoleic and canola141Soybean and fish lavender138Canola and sesame16Hexanoic and fish canola and sesame103Linoleic and linesed142Soybean and lavender183Canola and lavender18Hexanoic and lavender63Corn and mineral los103Linoleic and lavender144Linoleic and lavender185Canola and lavender19Hexanoic and linesed64Corn and glycerol linesed105Linoleic and canola145Fish and lavender186Canola and lavender20Hexanoic and linesed64Corn and glycerol linesed144Soybean and linesed186Canola and linesed186Canola and linesed21Cotonseed and saftower70Olic and onoybean linesed145Fish and mineral<			,		
11 Hexanoic and safflover 52 Corn oil only 96 Peanut and glycerol 136 Soybean and seme 177 Sunflower and mineral 12 Hexanoic and seme 56 Corn and sunflower 98 Linoleic and oil 137 Soybean and sesame 138 Soybean and sesame 138 Soybean and sesame 138 Soybean and sesame 138 Corn and sesame 141 Soybean and sesame 138 Canola and inneral to linoleic and corn 141 Soybean and sesame 138 Canola and sesame 138 Canola and sesame 141 Soybean and sesame 138 Canola and sesame 142 Soybean and sesame 143 Soybean and sesame 143 Soybean and sesame 143 Canola and sesame 143 Canola and sesame 143 Canola and sesame 13 Hexanoic and finared 60 Corn and sighcerol 116 Linoleic and anoic 144 Soybean and sesame 144					
safflower53Corn and cottonseed97Linoleic acid only to Corn and safflower97Linoleic acid only to Staffower and tayenderimment tayender178Sunflower and tayender13Hexanoic and canob55Corn and safflower100Linoleic and olive138Soybean and canob tayender138Soybean and canob tayender138Soybean and fish tayender138Soybean and fish138Canob and sesame14Hexanoic and fishCorn and saft102Linoleic and panu138Soybean and fish138Canob and sesame15Hexanoic and fishCorn and mineral103Linoleic and141Soybean and fish138Canob and sesame16Hexanoic and63Corn and mineral103Linoleic and142Soybean and188Canob and dish18Hexanoic and64Corn and glycerol105Linoleic and144Soybean and184Canob and dish19Hexanoic and64Corn and glycerol105Linoleic and canob144Soybean and185Canob and dish20Hexanoic and66Olic and orn105Linoleic and canob144Soybean and184Canob and dish21Cotonseed and70Olic and orn105Linoleic and canob145Fish and fish188Mineral and23Cotonseed and70Olic and orn104Linoleic and casor147Fish and glycerol148 <td></td> <td></td> <td></td> <td></td> <td></td>					
12 Hexanoic and sunflower 54 Corn and sufflower 98 Linoleic and olive 137 Soybean and canoba 17 Soybean and canoba 180 Canola oli only 15 Hexanoic and fish 60 Corn and fish 101 Linoleic and coron 140 Soybean and 180 Canola and sesame 16 Hexanoic and 61 Corn and fish 120 Coron and fish 120 Coron and invender 183 Canola and sesame 183 Canola and sesame 184 Canola and fish 185 Canola and fish 186 Canola and 184 Canola and 185 Canola and 186 Canola and <td></td> <td>2</td> <td></td> <td>5</td> <td></td>		2		5	
sunflower55Corm and sufflowersoybean138Soybeanlawender13Hexanoic and canoda57Corm and canola100Linoleic and peanut139Soybean and fish180Canola oil oil y15Hexanoic and castor59Corm and eastor101Linoleic and peanut134Soybean and fish180Canola and castor16Hexanoic and fish60Corm and mineral103Linoleic and141Soybean and182Canola and castor17Hexanoic and63Corm and mineral103Linoleic and143Soybean and184Canola and fish18Hexanoic and63Corm and glycerol105Linoleic and144Soybean and185Canola and fish19Hexanoic and66Oleic and glycerol105Linoleic and canola144Soybean and186Canola and fish19Hexanoic and66Oleic and soybean107Linoleic and canola144Soybean and186Canola and20Hexanoic and60Oleic and soybean107Linoleic and canola147Sinhand187Canola and21Cottonseed and70Oleic and softwore106Linoleic and canola147Fish and188Canola and22Cottonseed and71Oleic and safthower110Linoleic and canola148Fish and188Canola and23Cottonseed and71Oleic and saft					
13 Hexanoic and canda 56 Corn and canda 99 Linoleic and peanut sesame 17 PS sunflower and fish 15 Hexanoic and castor 50 Corn and castor 10 Linoleic and corn 140 Soybean and castor 180 Canada and sesame 16 Hexanoic and fish 60 Corn and fish 102 Linoleic and corn 140 Soybean and fish 182 Canada and sesaror 17 Hexanoic and 61 Corn and lavender 133 Canola and fish 182 Canola and fish 184 Canola and fish 186 Canola and 188 Mineral and 186 Canola and 180 Mineral and 186 Canola and 189 Mineral and </td <td></td> <td></td> <td></td> <td>5</td> <td></td>				5	
sesame58Corn and sesame101Linoleic and cator140Soybean and fish150Canola and sesame15Hexanoic and fish60Corn and fish102Linoleic and142Soybean and181Canola and sesame16Hexanoic and61Corn and lavenderInseed142Soybean and182Canola and castor18Hexanoic and63Corn and lavenderInseed143Soybean and184Canola and mineral19Hexanoic and64Corn and glycerol105Linoleic and144Soybean and185Canola and mineral19Hexanoic and66Oleic and olive106Linoleic and castor144Fish and mineral186Canola and mineral20Hexanoic and66Oleic and olive107Linoleic and castor144Fish and mineral188Kanola and21Cottonseed and60Oleic and olivesesame147Fish and lavender188Mineral and21Cottonseed and70Oleic and cottonseed109Linoleic and castor144Fish and lavender189Mineral and23Cottonseed and70Oleic and castor100Linoleic and fish182Linoleic and147Fish and lavender180Mineral and24Cottonseed and70Oleic and castor101Linoleic and fish182Linoleic and151Linseed and191Mineral and				~	179 Sunflower and
15Hexanoic and castor59Corm and fish 61102Linoleic and mineral141Soybean and 142181Canola and castor17Hexanoic and mineral62Corm and mineral103Linoleic and mineral142Soybean and mineral183Canola and castor18Hexanoic and lavender63Corm and lexadecane104Linoleic and safflower143Soybean and mineral184Canola and distor19Hexanoic and decane64Corn and glycerol105Linoleic and safflower144Soybean and mineral185Canola and mineral lavender19Hexanoic and exadecane66Oleic and dinoleic of Oleic and soybean105Linoleic and lof144Soybean and mineral186Canola and mineral21Cottonseed oil only 22660leic and doive of esame106Linoleic and canola 107187Canola and mineral189Mineral and hexadecane23Cottonseed and safflower71Oleic and castor of 100109Linoleic and mineral130Linoleic and safflower144Fish and lavender tavender189Mineral and hexadecane24Cottonseed and sasame76Oleic and dastor of 27111Linoleic and mineral150Linseed and tavender190Mineral and sasame26Cottonseed and sasame77Oleic and dastor py Oleic and mineral and sasame <td>14 Hexanoic and</td> <td>57 Corn and canola</td> <td>100 Linoleic and peanut</td> <td>139 Soybean and castor</td> <td>glycerol</td>	14 Hexanoic and	57 Corn and canola	100 Linoleic and peanut	139 Soybean and castor	glycerol
16Hexanoic and mineral60Corm and mineral nocortonseed 103glycerol' 103182Canola and castor mineral18Hexanoic and lavender62Corn and lavender hexadecane104Linoleic and inseedmineral lavender143Soybean and hexadecane184Canola and castor hexadecane19Hexanoic and lexadecane66Oleic acid only of Oleic and insoleic105Linoleic and safflower143Soybean and hexadecane186Canola and mineral lavender20Hexanoic and glycerol66Oleic acid soybean of Oleic and opeanut 107Linoleic and sesame145Fish aid almineral lavender186Canola and mineral21Cottonseed and safflower70Oleic and cottonseed and cottonseed and cottonseed afflower108Linoleic and fish mineral147Fish and alyender lavender188Mineral oil only hexadecane23Cottonseed and safflower70Oleic and safflower and cator110Linoleic and mineral151Linseed and safflower197Mineral and hexadecane24Cottonseed and fo70Oleic and safflower and same112Linoleic and mineral151Linseed and safflower192Sesame and fo25Cottonseed and fo70Oleic and mineral all112Linoleic and mineral152Linseed and safflower193Sesame and fo26Cottonseed and <td>sesame</td> <td>58 Corn and sesame</td> <td>101 Linoleic and corn</td> <td>140 Soybean and fish</td> <td>180 Canola oil only</td>	sesame	58 Corn and sesame	101 Linoleic and corn	140 Soybean and fish	180 Canola oil only
17Hexanoic and mineral61Corn and lavender linseed142143Canola and mineral18Hexanoic and lavender62Corn and hexadecane103Linoleic and safflower143Soybean and hexadecane184Canola and mineral10Hexanoic and educateane63Olcic acid only olici acid only105Linoleic and sunflower144Soybean and hexadecane185Canola and mineral20Hexanoic and educateane60Olcic and finolei and olive106Linoleic and canota unineral144Soybean and hexadecane186Canola and mineral21Cottonseed oil only educateane69Olcic and oorn106Linoleic and castor inneral145Fish and lavender188Mineral and hexadecane23Cottonseed and canola71Olcic and asunflower r109Linoleic and fish inneral145Fish and lavender188Mineral and safflower24Cottonseed and r73Olcic and sunflower r111Linoleic and inneral150Linseed and safflower190Mineral and safflower25Cottonseed and r76Olcic and sunflower r114Oltic and assame152Linseed and safflower192Sesame and 		59 Corn and castor	102 Linoleic and		
mineral62Corn and lavenderInseedmineral'mineral'bexadecane18Hexanoic and63Corn and glycerol104Linoleic and143Soybean and184Canola and fish19Hexanoic and64Corn and glycerol105Linoleic and144Soybean and185Canola and mineral20Hexanoic and66Oleic acid only66Oleic and isobean106Linoleic and canola144Soybean and187Canola and21Cottonseed and69Oleic and opeanut106Linoleic and canola147Fish and lavender188Mineral al only23Cottonseed and70Oleic and cottonseed108Linoleic and148Fish and lavender188Mineral and23Cottonseed and70Oleic and canola110Linoleic and149Fish and glycerol190Mineral and24Cottonseed and77Oleic and safflower110Linoleic and151Linseed and193Sesame and25Cottonseed and77Oleic and and sesame113Linoleic and114154Linseed and193Sesame and26Cottonseed and79Oleic and fish114Olice and115Linseed and canola194Sesame and27Cottonseed and81Oleic and114Olice and115Linseed and canola114Sesame and27Cottonseed and83 <t< td=""><td></td><td></td><td></td><td></td><td></td></t<>					
18Hexanoic and lavender63Corn and glycerol104Linoleic and saflower184Canola and fish lavender19Hexanoic and hexadecane64Corn and glycerol105Linoleic and sunflower144Soybean and lavender186Canola and mineral20Hexanoic and glycerol60Oleic acid only est and bio card fish106Linoleic and fash sesame145Fish oil only187Canola and lavender21Cottonseed oil only est and bio card cand60Oleic and fish est and corn106Linoleic and fash sesame147Fish and mineral lavender188Mineral oil only22Cottonseed and safflower71Oleic and safflower110Linoleic and fash mineral150Linseed oil only hexadecane188Mineral and hexadecane23Cottonseed and sunflower73Oleic and safflower111Linoleic and nineral151Linseed and mineral190Mineral and hexadecane24Cottonseed and routonseed and routo and sesame76Oleic and safflower111Linoleic and lavender152Linseed and mineral192Sesame oil only mineral25Cottonseed and routo and cator70Oleic and fish glycerol122Linoleic and lavender152Linseed and mineral194Sesame and fish mineral26Cottonseed and mineral70Oleic and fish glycerol120Nice and sunflo				5	
lavenderhexadecanesafflowerlavender185Canola and mineral19Hexanoic and64Corn and glycerol105Linoleic and canola144Soybean and186Canola and20Hexanoic and66Oleic and lonoleic106Linoleic and canola147Soybean and187Canola and21Cottonseed oil only68Oleic and obvean107Linoleic and canola146Fish and lavender188Mineral oil only22Cottonseed and70Oleic and corn109Linoleic and fish148Fish and lavender188Mineral and135Catonseed and70Oleic and safflower110Linoleic and151Linseed canol190Mineral and347Oleic and sorn110Linoleic and151Linseed and190Mineral and347Cottonseed and76Oleic and safflower112Linoleic and151Linseed and190Mineral and35Cottonseed and77Oleic and seame112Linoleic and151Linseed and190Mineral and36Cottonseed and77Oleic and seame113Linoleic and151Linseed and190Mineral36Cottonseed and77Oleic and seame113Linoleic and154Linseed and194Sesame and37Cottonseed and79Oleic and fish114Olive and canola154Linseed and195 </td <td></td> <td></td> <td></td> <td></td> <td></td>					
19Hexanoic and hexadecane64Corn and glycerol105Linoleic and sunflower186Canola and hexadecane20Hexanoic and glycerol60Oleic and inoleic100Linoleic and canola145Fish oli only187Canola and hexadecane21Cottonseed oil only60Oleic and shower100Linoleic and fish147Fish and mineral188Mineral oil only23Cottonseed and sufflower71Oleic and stafflower109Linoleic and fish150Linseed190Mineral and24Cottonseed and sunflower73Oleic and safflower111Linoleic and151Linseed and191Mineral and25Cottonseed and canola76Oleic and safflower112Linoleic and151Linseed and192Sesame and fish24Cottonseed and canola76Oleic and fish glycerolglycerol152Linseed and193Sesame and fish25Cottonseed and castor70Oleic and livender114Olive and peanut153Linseed and194Sesame and26Cottonseed and mineral70Oleic and glycerol114Linoleic and154Linseed and195Sesame and27Cottonseed and mineral70Oleic and glycerol115Linseed and canola196Castor oil only28Cottonseed and mineral82Oleic and glycerol114Olive and fish1				5	
hexadecane65Oleic actiC only 66sunflowerhexadecanelasender20Hexanoic and glycerol66Oleic and linoleic106Linoleic and canola145Fish and mineral 147Fish and mineral glycerol187Canola and glycerol21Cottonseed and sunflower70Oleic and corn108Linoleic and castor148Fish and linoleic and rand188Mineral and mineral23Cottonseed and sunflower73Oleic and sunflower110Linoleic and linoleic and canola111Linoleic and linoleic and lawender150Linseed ond sufflower190Mineral and glycerol24Cottonseed and sufflower75Oleic and sufflower111Linoleic and lawender150Linseed and sufflower191Mineral and glycerol25Cottonseed and sesame77Oleic and sufflower113Linoleic and lawender153Linseed and canola192Sesame and castor26Cottonseed and fish79Oleic and mineral sufflower114Olive and canola154Linseed and canola194Sesame and sufflower28Cottonseed and fish80Oleic and glycerol115Olive and safflower196Sesame and lawender29Cottonseed and fish81Oleic and glycerol118Olive and safflower126Linseed and lawender197Sesame and lawender31Cottonseed and fish					
20Hexanoic and glycerol66Oleic and inoleic of Oleic and soybean 67107Linoleic and canola assame145Fish oil only Fish and mineral 147188Mineral and By Mineral and By Mineral and Inoleic and canola assame21Cottonseed oil only 22Cottonseed and sufflower70Oleic and coron 70108Linoleic and canor 109118Mineral and Inventer188Mineral and Inventer23Cottonseed and sufflower71Oleic and safflower 71101Linoleic and fish Inventer111Linoleic and seame111Linoleic and timeral111Linoleic and timeral111Linoleic timeral112Linseed timeral113Linseed timeral114115Linseed timeral119Mineral and timeral24Cottonseed and canola75Oleic and safflower r111Linoleic and timeral112Linoleic and timeral112Linseed and timeral113Linseed and timeral114115Linseed and timeral113Linseed timeral113Linseed timeral113Linseed timeral113Linseed timeral114Linelic and timeral115Linseed timeral115Linseed timeral115Linseed timeral114115Linseed timeral115Linseed timeral115Linseed timeral115Linseed timeral115Linseed timeral115Linseed timeral115Li					
glycerol67Oleic and soybean107Linoleic and146Fish and Inveralglycerol21Cottonseed and68Oleic and olivesesame147Fish and Iavender188Mineral and21Cottonseed and70Oleic and corn109Linoleic and fish148Fish and Iavender189Mineral and23Cottonseed and70Oleic and cottonseed110Linoleic and fish149Fish and glycerol190Mineral and24Cottonseed and73Oleic and sunflower111Linoleic and151Linseed and191Mineral and25Cottonseed and75Oleic and samflower112Linoleic and151Linseed and191Mineral and26Cottonseed and76Oleic and samehexadecanesafflower193Sesame and castor194Sesame and castor26Cottonseed and77Oleic and inneral114Olive and penut154Linseed and195Sesame and castor27Cottonseed and fish81Oleic and lavender115Olive and penut155Linseed and castor197Sesame and28Cottonseed and81Oleic and glycerol118Olive and safflower155Linseed and castor197Sesame and29Cottonseed and81Oleic and sero116Olive and safflower157Linseed and198Sesame and20Cottonseed and82 <td< td=""><td></td><td></td><td></td><td></td><td></td></td<>					
21Cottonseed and linseed68Oleic and olive oleic and contonseedsesame147Fish and lavender188Mineral oil only23Cottonseed and safflower70Oleic and cottonseed rot oleic and isseed109Linoleic and fish linseed and mineral148Fish and hexadecane189Mineral and lavender24Cottonseed and sunflower73Oleic and safflower rot oleic and cast rot oleic and cast rot oleic and cast rot oleic and cast rot oleic and safflower111Linoleic and linseed and linseed and linseed and safflower190Mineral and lavender24Cottonseed and sunflower75Oleic and canola rot oleic and castor linseed112Linoleic and linseed and linseed and linseed and linseed and sesame176Oleic and safflower rot oleic and castor linseed and fish linseed and linseed linseed and linseed196Castor oil only linseed linseed linseed and linseed linseed and linseed30Cottonseed and liveand sourceane84Peanut oil only lis118Olive and linseed lis155Linseed and lis198Sesame and lis31Cottonseed and liveand84Peanut ol only lis118<					
22Cottonseed and linseed69Oleic and peanut of Oleic and corm108Linoleic and castor 109148Fish and hexadecane189Mineral and lavender23Cottonseed and safflower71Oleic and tonseed mineral100Linoleic and fish mineral148Fish and glycerol190Mineral and hexadecane24Cottonseed and sunflower73Oleic and sunflower r111Linoleic and lavender149Fish and glycerol190Mineral and hexadecane25Cottonseed and sesame75Oleic and castor r112Linoleic and lavender151Linseed and sufflower192Sesame and castor26Cottonseed and sesame77Oleic and fish glycerol113Linoleic and lavender152Linseed and sufflower194Sesame and castor27Cottonseed and mineral79Oleic and lavender sesame and hexadecane115Olive and castor lavender154Linseed and castor lase lawender195Sesame and sesame and lavender28Cottonseed and mineral80Oleic and glycerol118Olive and sufflower157Linseed and lavender198Sesame and lavender31Cottonseed and hexadecane83Peanut ol only lavender118Olive and sufflower159Linseed and lavender199Sesame and lavender32Cottonseed and linoleic84Peanut and corn120Ol		2			
linseed70Oleic and cortonseed109Linoleic and fishhexadecanelavender23Cottonseed and71Oleic and safflower120Dieic and safflower149Fish and glycerol190Mineral and24Cottonseed and73Oleic and safflower111Linoleic and151Linseed oil onlyhexadecane25Cottonseed and75Oleic and canola112Linoleic and152Linseed and193Sesame oil only26Cottonseed and77Oleic and canola112Linoleic and153Linseed and194Sesame and fish28Cottonseed and fish78Oleic and fish114Olive oil onlymineralmineral28Cottonseed and fish81Oleic and linered116Olive and corn155Linseed and sesame196Castor oil only29Cottonseed and83Oleic and glycerol116Olive and corn158Linseed and198Sesame and20Cottonseed and84Peanut and corn119Olive and safflower158Linseed and198Sesame and20Cottonseed and84Peanut and corn119Olive and safflower159Linseed and199Sesame and31Cottonseed and84Peanut and corn119Olive and safflower159Linseed and199Sesame and32Cottonseed and199Cesator and fish120Olive and safflower	5				2
safflower72Oleic and linseedmineral150Linseed alhexadecane24Cottonseed and73Oleic and safflower111Linoleic and151Linseed and191Mineral and25Cottonseed and75Oleic and safflower112Linoleic and151Linseed and192Sesame oli only26Cottonseed and77Oleic and sesame113Linoleic and153Linseed and canola193Sesame and castor26Cottonseed and77Oleic and fishglycerol113Linoleic and153Linseed and canola194Sesame and castor27Cottonseed and79Oleic and lavender115Olive and peanut155Linseed and canola196Castor oil only28Cottonseed and81Oleic and glycerol115Olive and corn156Linseed and fishLavender29Cottonseed and82Oleic and glycerolcottonseed158Linseed and198Sesame and30Cottonseed and82Oleic and glycerol118Olive and canola159Linseed and198Sesame and31Cottonseed and84Peanut and corn119Olive and canola160Linseed and199Sesame and32Cottonseed and82Oleic and glycerol118Olive and canola160Linseed and200Castor and fish33Octanoic and124Olive and castor125 </td <td>linseed</td> <td></td> <td>109 Linoleic and fish</td> <td>hexadecane</td> <td>lavender</td>	linseed		109 Linoleic and fish	hexadecane	lavender
safflower72Oleic and linseedmineral150Linseed oil onlyhexadecane24Cottonseed and73Oleic and safflower111Linoleic and151Linseed and191Mineral and25Cottonseed and75Oleic and sanflower112Linoleic and151Linseed and192Sesame oil only26Cottonseed and77Oleic and sesame113Linoleic and153Linseed and canola194Sesame and castor27Cottonseed and77Oleic and fishglycerol114Olive oil only154Linseed and canola195Sesame and castor28Cottonseed and79Oleic and nineral114Olive oil only155Linseed and canola196Castor oil only28Cottonseed and180Oleic and glycerol115Olive and canola157Linseed and fishLavender29Cottonseed and81Oleic and glycerolcottonseed157Linseed and197Sesame and30Cottonseed and83Peanut and corn118Olive and safflower159Linseed and198Sesame and31Cottonseed and84Peanut and corn119Olive and canola159Linseed and199Sesame and32Cottonseed and84Peanut and corn119Olive and safflower160Linseed and200Castor and fish33Octanoic and124Olive and canola<	23 Cottonseed and	71 Oleic and cottonseed	110 Linoleic and	149 Fish and glycerol	190 Mineral and
sunflower74Oleic and sunflowerlavendersafflowersafflowerglycerol25Cottonseed and76Oleic and seame112Linoleic and152Linseed and192Sesame oil only26Cottonseed and77Oleic and casor113Linoleic and153Linseed and canola194Sesame and fish26Cottonseed and78Oleic and nineralglycerol114Olive oil only154Linseed and castor195Sesame and27Cottonseed and fish81Oleic and nineral115Olive and peanut115Olive and peanut155Linseed and sesame196Castor oil only28Cottonseed andhexadecane117Olive and safflower156Linseed and sesame196Castor oil only20Cottonseed and83Peanut oil only118Olive and safflower158Linseed and198Sesame and31Cottonseed and83Peanut and corn121Olive and safflower160Linseed and199Sesame and32Cottonseed and122Olive and safflower160Castor and fish200Castor and fish202Castor and fish33Octanoic and oleic124Olive and fish125Olive and safflower163Safflower and203Castor and fish36Octanoic and125Olive and fish126Olive and fish207Castor and glycerol36Octanoic	safflower	72 Oleic and linseed	mineral		hexadecane
25Cottonseed and canola75Oleic and canola112Linoleic and hexadecane152Linseed and sunflower193Sesame oil only26Cottonseed and resame77Oleic and fish glycerol113Linoleic and glycerol153Linseed and canola 154194Sesame and fish mineral27Cottonseed and resame79Oleic and mineral lawender114Olive and peanut 115154Linseed and canola unineral195Sesame and fish mineral28Cottonseed and mineral81Oleic and lawender mineral116Olive and peanut 116155Linseed and castor 155196Castor oil only 15520Cottonseed and hexadecane83Peanut and corn118Olive and seame 119159Linseed and lawender198Sesame and hexadecane30Cottonseed and hexadecane84Peanut and corn118Olive and sesame 120159Linseed and lawender199Sesame and hexadecane31Cottonseed and glycerol201Castor and mineral lawender121Olive and sesame lawender161Safflower and sunflower200Castor and lawender33Octanoic and soybean33Octanoic and doive126Olive and lawender162Safflower and sesame205Castor and glycerol castor34Octanoic and soybean0Octanoic and doive126Olive and lawender164Safflower and		73 Oleic and safflower	111 Linoleic and		
canola76Oleic and sesamehexadecanesunflower193Sesame and castor26Cottonseed and77Oleic and castor113Linoleic and154Linseed and canola194Sesame and fish27Cottonseed and79Oleic and mineralglycerol114Olive and lownder115Linseed and canola195Sesame and fish28Cottonseed and81Oleic and116Olive and corn155Linseed and castor197Sesame and29Cottonseed andhexadecane117Olive and corn156Linseed and fishLavender30Cottonseed andhexadecane119Olive and safflower159Linseed and198Sesame and31Cottonseed and84Peanut and corn119Olive and safflower160Linseed and190Sesame and32Cottonseed and112Olive and safflower160Linseed and190Sesame and32Cottonseed and112Olive and safflower160Linseed and190Sesame and33Octanoic and oleic122Olive and safflower161Safflower and200Castor and fish33Octanoic and oleic123Olive and fish124Olive and fish202Castor and lavender34Octanoic and solue124Olive and lavender163Safflower and205Castor and glycerol36Octanoic and solue126Olive an					
26Cottonseed and sesame77Oleic and fish fish113Linoleic and glycerol153Linseed and Linseed and mineral194Sesame and fish mineral27Cottonseed and mineral79Oleic and hivender state114Olive oil only115Linseed and sesame196Castor oil only28Cottonseed and mineral81Oleic and glycerol115Olive and peanut115Linseed and sesame196Castor oil only29Cottonseed and mineral82Oleic and glycerol116Olive and corn156Linseed and sesame197Sesame and30Cottonseed and hexadecane83Peanut oil only118Olive and safflower158Linseed and lavender198Sesame and31Cottonseed and glycerol84Peanut and corn120Olive and safflower160Linseed and glycerol200Castor and fish33Octanoic and olive122Olive and castor162Safflower oil only203Castor and hivender34Octanoic and soybean124Olive and lavender163Safflower and sunflower205Castor and glycerol36Octanoic and gloc126Olive and lavender163Safflower and sesame205Castor and glycerol36Octanoic and soybean126Olive and lavender163Safflower and sesame205Castor and glycerol37Octanoic and soybean164					2
sesame78Oleic and fish 79glycerol154Linseed and mineral195Sesame and mineral27Cottonseed and rastor78Oleic and mineral 80Oleic and mineral 115114Olive oil only 115Diseed and peanut 115Diseed and peanut 1156Linseed and sesame Linseed and fish196Castor oil only28Cottonseed and hexadecane81Oleic and glycerol avender117Olive and only cottonseed at and corn156Linseed and fish LavenderLavender30Cottonseed and hexadecane82Peanut oil only avender118Olive and safflower aunt and corn158Linseed and Lavender198Sesame and hexadecane31Cottonseed and hexadecane84Peanut and corn119Olive and safflower aunflower159Linseed and Lavender199Sesame and hexadecane32Cottonseed and glycerol121Olive and castor160Linseed and Lavender200Castor and fish glycerol33Octanoic and oleic123Olive and castor162Safflower and sufflower and castor204Lavender and glycerol36Octanoic and olive125Olive and lavender163Safflower and castor205Castor and glycerol castor and37Octanoic and olive126Olive and lavender163Safflower and sesame204Lavender and sesame38Octanoic and corn126Olive and					
27Cottonseed and castor79Oleic and mineral 800leic and lavender114Olive oil only 115mineralmineralmineral28Cottonseed and fish mineral81Oleic and glycerol115Olive and peanut155Linseed and castor197Sesame and30Cottonseed and hexadecane83Peanut oil only118Olive and linseed159Linseed and lavender198Sesame and hexadecane31Cottonseed and hexadecane84Peanut and corn118Olive and safflower159Linseed and lavender199Sesame and glycerol32Cottonseed and hexadecane120Olive and canola sunflower100Linseed and lavender199Sesame and glycerol33Octanoic and oleic124Olive and castor 125161Safflower and sunflower203Castor and mineral glycerol36Octanoic and olive126Olive and lavender163Safflower and sesame205Castor and glycerol37Octanoic and corn126Olive and lavender164Safflower and sesame206Lavender and glycerol38Octanoic and corn166Safflower and fish 167206Lavender and glycerol206Lavender and glycerol39Octanoic and corn166Safflower and fish 167209Hexadecane and glycerol40Octanoic and cottonseed168Safflower and fish209					
castor80Oleic and lavender115Olive and peanut155Linseed and sesame196Castor oil only28Cottonseed and19Sesame and117Olive and corn156Linseed and castor197Sesame and30Cottonseed and83Peanut oil only118Olive and safflower157Linseed and fishLavender31Cottonseed and84Peanut and corn119Olive and safflower159Linseed and198Sesame and32Cottonseed and84Peanut and corn119Olive and safflower159Linseed and199Sesame and32Cottonseed and120Olive and safflower160Linseed and200Castor and fish120Castor and fish32Cottonic and olicic121Olive and sesame161Safflower oil only202Castor and fish202Castor and lavender33Octanoic and oleic124Olive and sesame162Safflower and203Castor and lavender34Octanoic and olive125Olive and lavender126Olive and lavender163Safflower and204Lavender and39Octanoic and corn126Olive and lavender164Safflower and208Hexadecane39Octanoic and corn166Safflower and208Hexadecane108108Hexadecane40Octanoic and corn166Safflower and209Hexadecane1					
28Cottonseed and fish mineral81Oleic and hexadecane116Olive and corn156Linseed and castor197Sesame and Lavender30Cottonseed and lavender82Oleic and glycerol118Olive and cottonseed157Linseed and fish Lavender198Sesame and hexadecane31Cottonseed and hexadecane84Peanut and corn118Olive and sufflower159Linseed and hexadecane199Sesame and hexadecane32Cottonseed and hexadecane121Olive and safflower sufflower160Linseed and glycerol200Castor and fish 200201Castor and fish hexadecane33Octanoic acid only storoic and oleic124Olive and fish 125Olive and fish sufflower203Castor and hexadecane36Octanoic and olive sophean126Olive and lavender163Safflower and castor205Castor and glycerol sufflower38Octanoic and corn cottonseed198Safflower and castor206Lavender and hexadecane207Lavender and hexadecane39Octanoic and cottonseed198Safflower and cottonseed208Hexadecane and mineral39Octanoic and cottonseed166Safflower and fo7209Hexadecane and mineral41Octanoic and cottonseed168Safflower and fo7210Glycerol only alkecane42Octanoic and10168					
29Cottonseed and mineralhexadecane117Olive and cottonseed157Linseed and fish 158Lavender30Cottonseed and hexadecane83Peanut oil only118Olive and safflower158Linseed and hexadecane198Sesame and hexadecane31Cottonseed and hexadecane84Peanut and corn119Olive and safflower159Linseed and hexadecane199Sesame and hexadecane32Cottonseed and hexadecane121Olive and canola sunflower160Linseed and hexadecane200Castor and fish Lavender33Octanoic acid only123Olive and castor161Safflower oil only 203203Castor and mineral 20320434Octanoic and oleic soybean125Olive and fish 125Castor163Safflower oil only 203203Castor and 20320436Octanoic and olive soybean126Olive and lavender164Safflower and sesame205Castor and glycerol 20520639Octanoic and corn126Olive and lavender165Safflower and sesame207Lavender and sesame39Octanoic and corn165Safflower and sesame208Hexadecane208Hexadecane39Octanoic and corn166Safflower and sesame209Hexadecane208Hexadecane41Octanoic and corn166Safflower and sesame209Hexadecane			1		5
mineral82Oleic and glycerolcottonseed158Linseed and198Sesame and30Cottonseed and84Peanut oil only118Olive and shafflower159Linseed and199Sesame and31Cottonseed and84Peanut and corn120Olive and shafflower160Linseed and120Castor and fish32Cottonseed and121Olive and safflower160Linseed and200Castor and fish33Octanoic acid only123Olive and castor161Safflower oil only202Castor and lavender34Octanoic and125Olive and fishcastor162Safflower and203Castor and34Octanoic and125Olive and fishcastor163Safflower and204Lavender and35Octanoic and126Olive and hineral163Safflower and205Castor and glycerol36Octanoic and olive126Olive and lavender164Safflower and205Castor and glycerol38Octanoic and corn166Safflower and fish208Hexadecane166Safflower and fish208Hexadecane39Octanoic and corn167Safflower and fish208Hexadecane and167Safflower and fish208Hexadecane and41Octanoic and156Safflower and167Safflower and209Hexadecane and42Octanoic and156Safflow					
30Cottonseed and lavender83Peanut oil only 84118Olive and linseed 119lavenderhexadecane31Cottonseed and hexadecane84Peanut and corn119Olive and safflower 120159Linseed and hexadecane199Sesame and glycerol32Cottonseed and glycerol121Olive and canola 122Olive and canola 122glycerol201Castor and fish glycerol33Octanoic acid only 34123Olive and castor162Safflower oil only 202203Castor and lavender34Octanoic and linoleic125Olive and mineral 126163Safflower and sunflower203Castor and hexadecane36Octanoic and soybean125Olive and havender163Safflower and sunflower205Castor and glycerol37Octanoic and olive soybean38Octanoic and corn126Olive and lavender166Safflower and sesame208Hexadecane39Octanoic and corn 40Octanoic and cottonseed166Safflower and fish glycerol208Hexadecane and mineral41Octanoic and cotanoic and199Octanoic and linseed160Safflower and sesame209Hexadecane and glycerol42Octanoic and199Octanoic and199Octanoic and209Hexadecane41Octanoic and199Safflower and linseed209Hexadecane and mineral209					
31 Cottonseed and hexadecane120 Olive and sunflowerhexadecaneglycerol32 Cottonseed and glycerol121 Olive and canola 122 Olive and dassame160 Linseed and glycerol200 Castor and fish glycerol33 Octanoic acid only123 Olive and castor162 Safflower oil only202 Castor and lavender34 Octanoic and oleic124 Olive and fish 125 Olive and fish203 Castor and lavender35 Octanoic and linoleic126 Olive and fish 126 Olive and lavender163 Safflower and sunflower204 Lavender and glycerol36 Octanoic and soybean126 Olive and lavender163 Safflower and sunflower205 Castor and glycerol37 Octanoic and olive166 Safflower and sesame205 Castor and glycerol and and glycerol164 Safflower and sesame205 Lavender oil only39 Octanoic and corn166 Safflower and sesame208 Hexadecane only adecane209 Hexadecane and glycerol39 Octanoic and corn166 Safflower and sesame209 Hexadecane and glycerol209 Hexadecane and glycerol40 Octanoic and linseed160 Safflower and linoleic206 Lavender oil only adecane207 Lavender and glycerol41 Octanoic and188 Safflower and linseed209 Hexadecane and mineral200 Glycerol only lavender208 Glycerol only lavender42 Octanoic and198 Safflower and lineed209 Hexadecane and mineral209 Hexadecane and glycerol32 Octanoic and198 Safflower and lineed209 Hexadecane and mineral209 Glycerol only lavender <td></td> <td></td> <td></td> <td></td> <td></td>					
hexadecanesunflower160Linseed and glycerol200Castor and fish glycerol32Cottonseed and glycerol121Olive and canola 122Olive and sesame161Safflower oil only202Castor and mineral 20333Octanoic acid only123Olive and castor162Safflower and203Castor and lavender34Octanoic and oleic124Olive and fish 125Castor and mineral163Safflower and204Lavender and35Octanoic and linoleic126Olive and fish 126Castorhexadecane04Lavender and36Octanoic and soybean126Olive and lavender163Safflower and205Castor and glycerol37Octanoic and olive126Olive and lavender164Safflower and205Castor and glycerol39Octanoic and corn166Safflower and fish208Hexadecane166Safflower and fish208Hexadecane and40Octanoic and cottonic and166Safflower and fish209Hexadecane and209Hexadecane and41Octanoic and urbered168Safflower and glycerol210Glycerol only210Glycerol only42Octanoic and106Safflower and209Hexadecane and209Hexadecane and32Octanoic and166Safflower and209Hexadecane and209Hexadecane and34Octanoic and	lavender	2	119 Olive and safflower	159 Linseed and	199 Sesame and
32Cottonseed and glycerol121Olive and canola 122Olive and canola 122Olive and canola 123Olive and sesame161Safflower oil only 202202Castor and lavender33Octanoic acid only123Olive and castor162Safflower and suflower and 203203Castor and lavender34Octanoic and olic124Olive and dish 125Castor and mineral 163Safflower and suflower and suflower and 205203Castor and hexadecane36Octanoic and soybean126Olive and lavender163Safflower and suflower205Castor and glycerol37Octanoic and olive126Olive and lavender165Safflower and sesame206Lavender oil only39Octanoic and corn166Safflower and fish sesame208Hexadecane only hexadecane and mineral209Hexadecane and mineral40Octanoic and cottonseed167Safflower and sesame209Hexadecane and mineral41Octanoic and under168Safflower and sesame210Glycerol only lavender42Octanoic and186Safflower and sesame210Glycerol only lavender	31 Cottonseed and		120 Olive and	hexadecane	glycerol
glycerol122Olive and sesame161Safflower oil only202Castor and lavender33Octanoic acid only123Olive and castor162Safflower and203Castor and34Octanoic and oleic124Olive and castor163Safflower and203Castor and35Octanoic and125Olive and fishcastorhexadecane36Octanoic and126Olive and lavender163Safflower and205Castor and glycerol37Octanoic and olive126Olive and lavender164Safflower and205Castor and glycerol37Octanoic and olive126Olive and lavender165Safflower and206Lavender oil only38Octanoic and corn165Safflower and fish208Hexadecanehexadecane39Octanoic and corn166Safflower and fish208Hexadecane only40Octanoic and167Safflower and209Hexadecane andacottonseed166Safflower and209Hexadecane and41Octanoic and168Safflower and210Glycerol only42Octanoic and106Safflower and210Glycerol only42Octanoic and180Safflower and210Glycerol only42Octanoic and180Safflower and210Glycerol only43Octanoic and180Safflower and210Glycerol only <td< td=""><td>hexadecane</td><td></td><td>sunflower</td><td>160 Linseed and</td><td>200 Castor and fish</td></td<>	hexadecane		sunflower	160 Linseed and	200 Castor and fish
33Octanoic acid only123Olive and castor162Safflower and203Castor and34Octanoic and oleic124Olive and fishcastorhexadecane35Octanoic and125Olive and mineral163Safflower and204Lavender and160Octanoic and126Olive and lavender163Safflower and204Lavender and36Octanoic and126Olive and lavender164Safflower and205Castor and glycerol37Octanoic and olive165Safflower and206Lavender oil only165Safflower and207Lavender and38Octanoic and corn166Safflower and fish208Hexadecane166Safflower and fish208Hexadecane only40Octanoic and167Safflower and fish209Hexadecane and209Hexadecane and41Octanoic and168Safflower and210Glycerol only210Glycerol only42Octanoic and168Safflower and210Glycerol only210Glycerol only					
34Octanoic and oleic124Olive and fish 125castorhexadecane35Octanoic and125Olive and mineral 126163Safflower and suflower204Lavender and glycerol36Octanoic and soybean126Olive and lavender163Safflower and suflower and canola205Castor and glycerol castor and glycerol37Octanoic and olive205Castor and glycerol canola206Lavender oil only38Octanoic and peanutsesamehexadecane207Lavender and hexadecane39Octanoic and corn166Safflower and fish tool and208Hexadecane only 20940Octanoic and167Safflower and glycerol209Hexadecane and mineral41Octanoic and168Safflower and glycerol210Glycerol only lavender42Octanoic and168Safflower and glycerol210Glycerol only lavender					
35Octanoic and linoleic125Olive and mineral 126163Safflower and sunflower204Lavender and glycerol36Octanoic and soybean126Olive and lavender164Safflower and canola205Castor and glycerol canola37Octanoic and olive205Castor and glycerol canola206Lavender oil only 207207Lavender oil only 20738Octanoic and peanutsesamehexadecane166Safflower and fish 167208Hexadecane only 20940Octanoic and166Safflower and fish nineral209Hexadecane and glycerol41Octanoic and168Safflower and and linseed210Glycerol only lavender42Octanoic and168Safflower and lavender210Glycerol only lavender					
linoleic126Olive and lavendersunflowerglycerol36Octanoic and205Castor and glycerolsoybean206Lavender oil only37Octanoic and olive165Safflower and20638Octanoic and peanutsesamehexadecane39Octanoic and corn166Safflower and fish208Hexadecane only40Octanoic and167Safflower and209Hexadecane andcottonseed167Safflower andglycerol168Safflower and41Octanoic and168Safflower and210Glycerol only42Octanoic andlavender108Safflower and210					
36Octanoic and soybean164Safflower and canola205Castor and glycerol canola37Octanoic and olive165Safflower and sesame206Lavender oil only38Octanoic and peanut165Safflower and sesame207Lavender and hexadecane39Octanoic and corn166Safflower and fish to Canoic and208Hexadecane only 20940Octanoic and cottonseed167Safflower and mineral209Hexadecane and glycerol41Octanoic and168Safflower and glycerol210Glycerol only lavender42Octanoic andlavender108Safflower and glycerol210					
soybeancanola206Lavender oil only37Octanoic and olive165Safflower and207Lavender and38Octanoic and peanutsesamehexadecane39Octanoic and corn166Safflower and fish208Hexadecane only40Octanoic and167Safflower and209Hexadecane andcottonseedmineralglycerol41Octanoic and168Safflower and210Glycerol only42Octanoic andlavender168Safflower and208			120 Onve and lavender		
37Octanoic and olive165Safflower and sesame207Lavender and hexadecane38Octanoic and peanutsesamehexadecane16639Octanoic and corn166Safflower and fish to Octanoic and208Hexadecane only40Octanoic and167Safflower and fish univerand209Hexadecane and glycerol41Octanoic and168Safflower and glycerol210Glycerol only lavender42Octanoic andlavender168Safflower and210					
38Octanoic and peanutsesamehexadecane39Octanoic and corn166Safflower and fish208Hexadecane only40Octanoic and167Safflower and209Hexadecane andcottonseedmineralglycerolglycerol41Octanoic and168Safflower and210Glycerol only42Octanoic andlavenderlavender168Safflower and					
39Octanoic and corn166Safflower and fish 208208Hexadecane only 20940Octanoic and cottonseed167Safflower and mineral209Hexadecane and glycerol41Octanoic and linseed168Safflower and 210210Glycerol only lavender42Octanoic andlavender168Safflower and210					
40 Octanoic and cottonseed167 Safflower and mineral209 Hexadecane and glycerol41 Octanoic and linseed168 Safflower and lavender210 Glycerol only lavender	I I I I I I I I I I I I I I I I I I I				
cottonseedmineralglycerol41Octanoic and linseed168Safflower and21042Octanoic andlavender168					
41Octanoic and linseed168Safflower and210Glycerol only42Octanoic andlavender	cottonseed				glycerol
	41 Octanoic and linseed			168 Safflower and	210 Glycerol only
safflower				lavender	
	safflower				