# ABBE VALUE & REFRACTIVE INDEX

## THE ONGOING BATTLE

1 HOUR CE CREDIT

ABO LEVEL II

1

## COURSE PRESENTATION

Today's Presenter

Phernell Walker, MBA, ABOM, LDO

Pure Optics

CE Program Written By

Andrew S. Bruce, LDO, ABOM, NCLE-AC

ASB Opticianry Education Services

MR™ by Mitsui Chemicals

Educational Sponsorship From Mitsui Chemicals

American Board of Opticianry

ABO Technical Level II

1 Credit Hour



2

## Phernell Walker, MBA, ABOM, LDO, NCLEC

- Principle | Pure Optics LLC
- Author | Pure Optics textbook
- American Board of Opticianry | Executive Board of Directors
- Vision Expo Opticon | Co-Chair Advisory Board of Directors
- Opticians Association of America | Board of Directors
- Pacific University College of Optometry | Past Adjunct Professor
- Master in Business Administration (MBA)
- Master in Ophthalmic Optics (ABOM)
- Associate in Science Ophthalmic Optics (AS)
- Licensed Dispensing Optician (WA-LDO)
- National Contact Lens Examiners Certified (NCLEC)

3

SCAN ME

**Phernell Walker, MBA, ABOM, LDO**

**w:** pure-optics.com

**e:** phernell@pure-optics.com

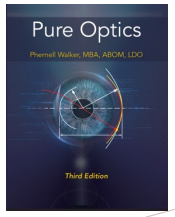
4

*REFERENCE RESOURCE*

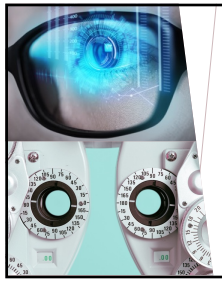
## Pure Optics

by

Phernell Walker, MBA, ABOM, LDO



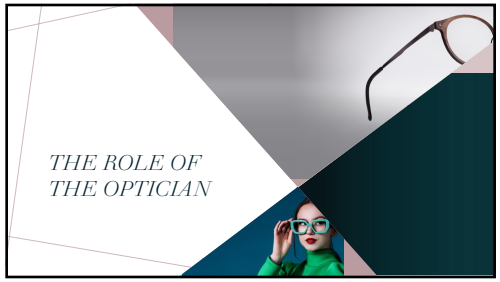

5



## *LEARNING OBJECTIVES*

1. Provide an overview of the science of light and ophthalmic optics
2. Define and discuss Abbe value and its relationship to dispersion and refractive index
3. Explore techniques to assist selection of the most appropriate lens material, based on refractive error and its complexity
4. Discuss ways to present different lens materials to patients, together with pros and cons for each.

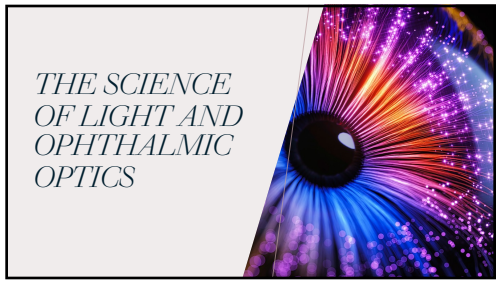
6


THE ROLE OF
THE OPTICIAN

7

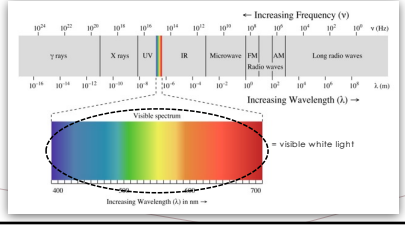

THE MANY HATS WORN BY THE OPTICIAN
Trusted professional to recommend the best eyewear solitons to provide optimal vision and pleasing cosmetics
Eyewear expert and patient guide
Uses the science of light and optics to fill an eyeglass prescription
Personal therapist, sometimes!
And many more...
Abbe Value & Refractive Index
2022

8


THE SCIENCE OF LIGHT AND OPHTHALMIC OPTICS

9

## THE ELECTROMAGNETIC SPECTRUM

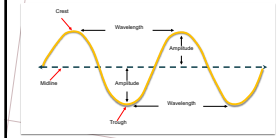


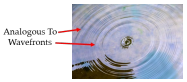

10

## WAVE THEORY OF LIGHT

**Huygen's Principle**

Light wave vibrates up and down, while traveling side to side



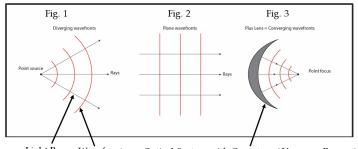




"Light is thought of as traveling away from a point, in the form of wavefronts, analogous to ripples in a pond"

Abbe Value & Refractive Index

11

## WAVEFRONTS, LIGHT RIGHTS, AND VERGENCE




Light travels away from a point source or object as diverging wavefronts

Hypothetical, perpendicular rays indicate direction of travel

Curvature of a wavefront or optical system indicates its vergence properties

12

# *REFRACTIVE INDEX, ABBE VALUE, AND DISPERSION*

13

## *REFRACTIVE INDEX*

$$\text{Refractive Index, } n = \frac{\text{Speed of light in a vacuum, } c}{\text{Speed of light in second medium, } v}$$

| LENS MATERIAL | REFRACTIVE INDEX |
|---|---|
| CR39 | 1.498 |
| Crown Glass | 1.530 |
| Polycarbonate | 1.586 |
| Trivex | 1.53 |
| MR-8™ | 1.60 |
| MR-10™ | 1.67 |
| MR-174™ | 1.74 |

**Refractive Index:** Ratio between speed of light in air to speed of light in a second medium *(in U.S. 587.56nm)*

- Refractive index is a measure of its refractive properties
- Higher refractive indices = thinner lens *(all else considered equal)*



14

## *HOW THIN WILL MY LENSES BE?*
### *Curve Variation Factor*

$$CVF = (n_1 - 1) / (n_2 - 1)$$

$n_1$ = index of initial material $n_2$ = index of compared material

| Lens Material | Percentage Thinner Compared to CR39 (RI 1.498) |
|---|---|
| Trivex | 6% Thinner |
| Polycarbonate | 15% Thinner |
| MR-8™/MR-95™ (1.60) | 17% Thinner |
| MR-10™ (1.67) | 26% Thinner |
| MR-174™ (1.74) | 33% Thinner |



15

## GEOMETRY OF LIGHT

"Opticians seek to control light. We can slow it down, redirect it, capture it, disperse it, and even compress it. But only temporarily"

*Phernell Walker, MBA, ABOM, LDO*



16

## REFRACTIVE INDEX DEFINED & IMPLICATIONS

- ***Refractive index*** - the ratio between lights velocity in air, compared to lights velocity in another transparent substrate
- ***Relevance*** - determines the materials efficiency at refracting light
- ***Implication*** - higher values equals greater efficiency and thinner lenses



17

## REFRACTIVE INDEX FORMULA

***Refractive Index*** - The ratio between the velocity of light through air compared to that of the new medium.

**n = 186,000 / velocity of light in a medium**

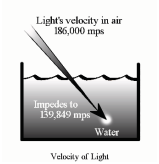
***Example:***
The speed of light through water is 139,849 miles per second
What is the refractive index of water?

n = 186,000 / 139,849
**n = 1.33**



18

## REFRACTIVE INDEX OF WATER






19

## ERNEST ABBE

- Lived (1840 – 1905)
- German physicist
- Microscope magnification limits
- Formulated the Abbe sine condition
- Measured chromatism

Source: Cambridge



20

## ABERRATION

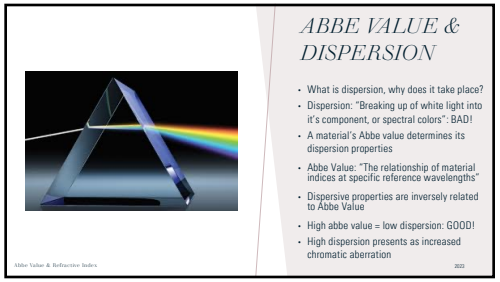
Aberration is the failure of lens system to bring light rays to a single focal point

- Imperfect image
- Chromatic vs. monochromatic

- substrate material
- lens index
- lens geometry
- mirror
- human eye



21

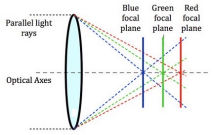


## ABBE VALUE & DISPERSION

- What is dispersion, why does it take place?
- Dispersion: "Breaking up of white light into it's component, or spectral colors": BAD!
- A material's Abbe value determines its dispersion properties
- Abbe Value: "The relationship of material indices at specific reference wavelengths"
- Dispersive properties are inversely related to Abbe Value
- High abbe value = low dispersion: GOOD!
- High dispersion presents as increased chromatic aberration

Abbe Value & Refractive Index 2023

22




## CHROMATIC ABERRATION

**Definition**
- An optical system focusing error
- Spectral components focused different distances from the lens

**Cause**
- Low Abbe value

**Result**
- Color fringes around images seen through lens periphery
- Visually distracting

Abbe Value & Refractive Index 2023

23

## ABBE VALUE & REFRACTIVE INDEX

| LENS MATERIAL | REFRACTIVE INDEX | ABBE VALUE |
|---|---|---|
| CR39 | 1.498 | 58 |
| Crown Glass | 1.530 | 59 |
| Polycarbonate | 1.586 | 30 |
| Trivex | 1.53 | 45 |
| MR-8™ | 1.60 | 41 |
| MR-10™ | 1.67 | 31 |
| MR-174™ | 1.74 | 32 |

How are Abbe value and refractive index related?

Generally, increasing refractive index results in a decreased Abbe Value

Increased potential for chromatic aberration

Abbe Value & Refractive Index 2023

24

## LONGITUDINAL CHROMATIC ABERRATION

**Longitudinal = FF (blue light) - FC (red light)**

- Dioptric Difference



25

## LONGITUDINAL CHROMATIC ABERRATION

**Longitudinal = D / v**

- D = lens dioptric power
- v = Abbe value



26

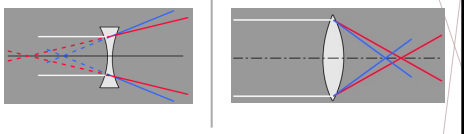
## TRANSVERSE CHROMATIC ABERRATION (TCA)

- **TCA** - components of light refract at different distances through the same lens
- **Chromatic aberration (chromatism)** - results in a noticeable color shift towards the edges of objects



27

## BLUE LIGHT SHORTER WAVELENGTH





28

## TRANSVERSE CHROMATIC ABERRATION (TCA)

**TCA = ($n_{yellow}$ - 1 ) / ($n_{blue}$ - $n_{red}$)**

- TCA = Transverse Chromatic Aberration
- $n_{yellow}$ = 589.3 nm
- $n_{blue}$ = 486.1 nm
- $n_{red}$ = 656.3 nm



29

## ABBE VALUE

- Abbe Value (nu) - reciprocal value measuring Transverse Chromatic Aberration (TCA)
- Measures the optical properties of a substrate vs. its mechanical attributes



30

## *TRANSVERSE / LATERAL CHROMATIC ABERRATION*

- **TCA** - measures the optical properties of a substrate vs. its mechanical attributes. TCA measures chromatism
- **LCA** - measures the amount of chroma in prism diopters in the periphery



31

## *LATERAL CHROMATIC ABERRATION (LCA)*

**LCA = P / Abbe**

- LCA = **L**ateral **C**hromatic **A**berration
- P = (hcm) (D) @ given meridian
- Abbe = Material's V value



32

## *CALCULATE LCA*

**LCA = P / Abbe**

- Calculate the LCA of $1.74_n$ @ 23mm
- Rx: -8.00 DS
- Abbe: 32



33

## CALCULATE LCA

**LCA = 18.4 / 32**

- Substrate = $1.74_n$ @ 23 mm
- P = -8.00 x 2.3 cm
- Abbe = 32
- LCA = 0.58▲ D



34

## CALCULATE LCA

**LCA = P / Abbe**

- Calculate the LCA of $1.586_n$ @ 23mm
- Rx: -8.00 DS
- Abbe



35

## CALCULATE LCA

**LCA = 18.4 / 30**

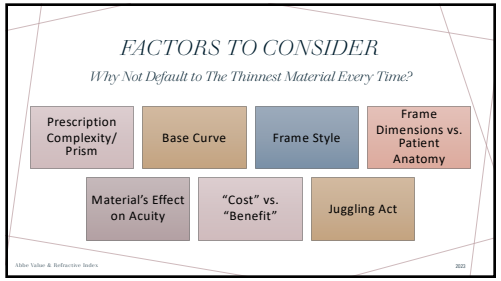
- Substrate = $1.586_n$ @ 23 mm
- P = -8.00 x 2.3 cm
- Abbe = 30
- LCA = 0.61▲ D



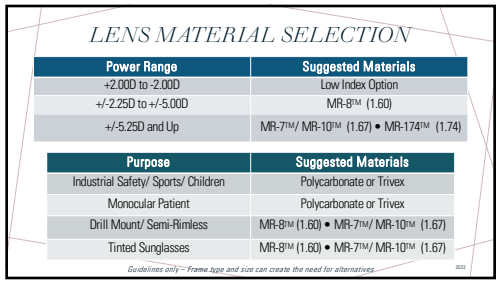
36


WHICH LENS MATERIAL IS BEST?

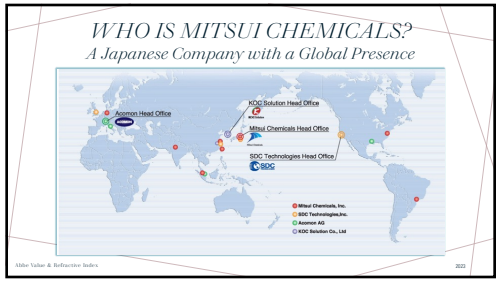
37


FACTORS TO CONSIDER
Why Not Default to The Thinnest Material Every Time?
Prescription Complexity/ Prism
Base Curve
Frame Style
Frame Dimensions vs. Patient Anatomy
Material's Effect on Acuity
"Cost" vs. "Benefit"
Juggling Act

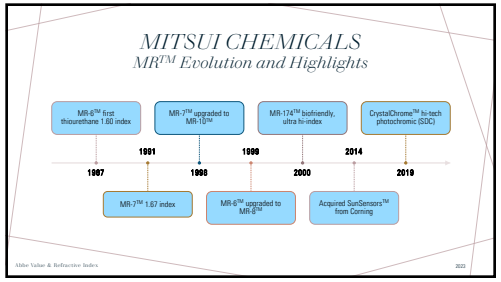
38


LENS MATERIAL SELECTION
Power Range
Suggested Materials
+2.00D to -2.00D
Low Index Option
+/-2.25D to +/-5.00D
MR-8™ (1.60)
+/-5.25D and Up
MR-7™/ MR-10™ (1.67) • MR-174™ (1.74)
Purpose
Suggested Materials
Industrial Safety/ Sports/ Children
Polycarbonate or Trivex
Monocular Patient
Polycarbonate or Trivex
Drill Mount/ Semi-Rimless
MR-8™ (1.60) • MR-7™/ MR-10™ (1.67)
Tinted Sunglasses
MR-8™ (1.60) • MR-7™/ MR-10™ (1.67)
Guidelines only – Frame type and size can create the need for alternatives

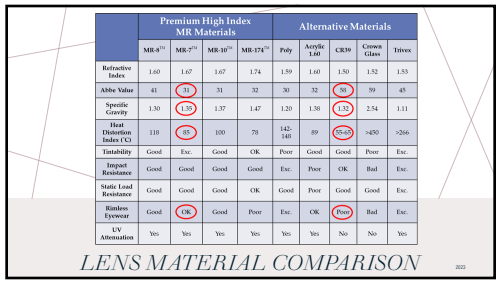
39


WHO IS MITSUI CHEMICALS?
A Japanese Company with a Global Presence
Acomon Head Office
KDC Solution Head Office
Mitsui Chemicals Head Office
SDC Technologies Head Office
SDC
Mitsui Chemicals, Inc.
SDC Technologies,Inc.
Acomon AG
KDC Solution Co., Ltd
Abbe Value & Refractive Index
2022

40


MITSUI CHEMICALS
MR™ Evolution and Highlights
MR-6™ first thiourethane 1.60 index
MR-7™ upgraded to MR-10™
MR-174™ biofriendly, ultra hi-index
CrystalChrome™ hi-tech photochromic (SDC)
1987
1991
1998
1999
2000
2014
2019
MR-7™ 1.67 index
MR-6™ upgraded to MR-8™
Acquired SunSensors™ from Corning
Abbe Value & Refractive Index
2022

41


Premium High Index MR Materials
Alternative Materials
MR-8™ MR-7™ MR-10™ MR-174™ Poly Acrylic 1.60 CR39 Crown Glass Trivex
Refractive Index 1.60 1.67 1.67 1.74 1.59 1.60 1.50 1.52 1.53
Abbe Value 41 31 31 32 30 32 58 59 45
Specific Gravity 1.30 1.35 1.37 1.47 1.20 1.38 1.32 2.54 1.11
Heat Distortion Index (°C) 118 85 100 78 142-148 89 95-65 >450 >266
Tintability Good Exc. Good OK Poor Good Good Poor Exc.
Impact Resistance Good Good Good Good Exc. Poor OK Bad Exc.
Static Load Resistance Good Good Good OK Good Poor Good Good Exc.
Rimless Eyewear Good OK Good Poor Exc. OK Poor Bad Exc.
UV Attenuation Yes Yes Yes Yes Yes Yes No No Yes
LENS MATERIAL COMPARISON
2022

42

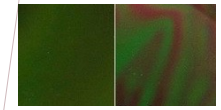
## PREMIUM HIGH INDEX BENEFITS

- Enhanced optical performance
- Superior impact resistance
- Excellent UV protection
- Easy to tint
- Excellent scratch resistance
- Enhanced durability for all frame types
- Index-matched hard coat

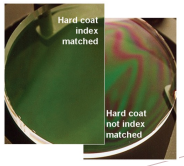
Abbe Value & Refractive Index 2022

43

## NAME THIS PHENOMENON



## WHAT CAUSES BIREFRINGENCE?




Abbe Value & Refractive Index 2022

44

## HOW TO PRESENT PREMIUM MATERIALS TO YOUR PATIENTS

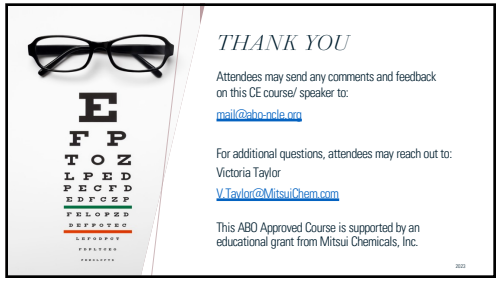
- Discuss Benefits = Perceived Value
- Personal Experience
- Illustrations
- Visual Aids
- Fabricated Examples
- Digital Measuring Device

Abbe Value & Refractive Index 2022

45


CONCLUSIONS
AND QUESTIONS

46


THANK YOU
Attendees may send any comments and feedback on this CE course/ speaker to:
mail@abo-ncle.org
For additional questions, attendees may reach out to:
Victoria Taylor
V.Taylor@MitsuiChem.com
This ABO Approved Course is supported by an educational grant from Mitsui Chemicals, Inc.

47